Sapira's Art & Science *of* Bedside Diagnosis

FOURTH EDITION

Jane M. Orient, M.D.

Clinical Lecturer in Medicine
University of Arizona College of Medicine
Tucson, Arizona

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Preface to the Fourth edition

From the day when the first members of councils placed exterior authority higher than interior, that is to say, recognized the decisions of men united in councils as more important and more sacred than reason and conscience; on that day began lies that caused the loss of millions of human beings and which continue their unhappy work to the present day.

—Leo Tolstoy

Since the first edition went to press, the revolution has proceeded apace. At hospital committee meetings these days, the disconnection between medicine as once taught by prerevolutionary physicians and medicine as now codified by compliance-minded, MBA-qualified "medical directors" is startling; the author feels as though she arrived at such meetings by time machine.

In the new "integrated delivery systems," the organizational chart reigns. Physicians are boxed into defined categories, next to the bottom of the chart, just above the patients; together with the patients (now known as "covered lives"), they form the "medical loss ratio."

It is a world of paradox. Talk of "ethics" generally means talk of "resource allocation," often by means once called unethical. One drowns in information, but the key of knowledge is lost. Facilities and personnel are present in excess, and yet they are scarce.

The scarcest item of all appears to be the clinician's time. Thirty seconds may be too long to spend searching for a reference. In some settings, there may be no time to look in the left ear if only the right one hurts, much less to listen to the patient's grief or despair. And when can today's managed provider stop and reflect?

Concepts are imported from industry, such as "six sigma quality"—the goal to reduce errors below 6 standard deviations from the mean of a normal distribution. This means that all but 3.4 out of 1 million patients are supposed to meet a certain indicator, such as timely Pap smears or mammograms, regardless of individual needs and desires.

Quality experts in industry do recognize that one cannot control outputs without controlling inputs—a fact that health policy experts seldom acknowledge. But even if we could control the behavior of patients and physicians, there remains the problem that human beings are not stamped from an industrial die. Even if not totally unique in genetic endowment, each human being has had a different interaction with the world.

As the art of medicine is being lost, the science is also threatened. "Evidence-based" medicine is coming to mean based on the consensus of a committee of experts: the Prussian *Geheim Rath* with many heads (and no heart). Clinical reasoning is replaced by following a practice "guideline" from one prescribed information bit to another, and a diagnosis means a number with five significant digits (never mind that the first one is dubious) attached to an appropriate procedure code. The very altar of truth—the autopsy table—is being dismantled.

It is telling that bureaucratic quality assessment is almost always based on process (read compliance) measures such as number of blood pressure determinations or prescriptions for the medication *du jour*, not outcome measures such as all-cause mortality or ability to function independently. Regardless of the reading on the "continuous quality improvement" dashboard, almost everyone on the front lines of patient care believes that American medicine and health are in decline.

Why, then, another edition of this book?

Medicine is a living thing that will survive and flourish, despite the dinosaurs of "health care delivery," and long after inhuman systems fail. There are still students who aspire to be physicians, not providers, gatekeepers, resource managers, or box-checkers. There are still those who consider medicine to be a human and a humane endeavor, not an industry. This book is to provide them a compass, a road map, and, perhaps, a little entertainment as they embark on an exciting journey of exploration, together with their most important teachers: their patients.

As students begin their foray into physical diagnosis, frequently feeling overwhelmed by the vast amount of data they must absorb, the most helpful piece of advice might be that offered in 1957 by neurologist Robert Wartenberg: "Mistakes in neurologic diagnosis are more likely to result from not *looking* enough than from not *knowing* enough."

—Jane M. Orient, M.D., 2009

Preface to the First edition

As the decay of the Chou Dynasty grew worse, studies were neglected and the scribes became more and more ignorant. When they did not remember the genuine character, they blunderingly invented a false one. These non-genuine characters, copied out again by other ignorant writers, became usual.

—L. Wieger, SJ, *Chinese Characters*

The goal of this book is to help the reader achieve the correct personal, metaphysical, and epistemologic perspectives on the artful science of clinical examination. This is not a textbook of medicine. In analogy to football, a textbook of medicine is the playbook. This book is about learning the skills of blocking, tackling, punting, passing, and so forth, so that one may execute the plays with diligence and facility.

The style is intentionally unusual, attempting to capture the excitement of actual rounds with diversions along the way. This should help to hold the attention of today's students and residents, who are often caught up in pointless memorizing and unproductive errand-running at the expense of scholastic preparation for the lifelong task of self-teaching.

This book is written with a sense of great sadness about American academic medicine and from a prerevolutionary point of view (the revolution in academic medicine having occurred about 1968,[1] when the intellectual approach to diagnosis and its attendant techniques of clinical examination fell into disrespect, superseded by an inappropriately exclusive reliance on dogma and modern technologic devices). If the current civilization preserves even more trivial records of its behavior than did the Sumerian culture, then the present text may be of interest to historians of future ages. Some may think that this book will be held in the same regard as the work of a 19th century translator of Galen, who believed that medicine could be greatly improved only if the ignorant physicians of his day had access to Galen's work. After devoting his life to translating Galen into modern languages, he found that his task had immediately become an exercise in obsolescence, due to the beginning of the scientific era of medicine. Yet, one daily observes patients for whom the history and physical examination could lead one to the correct diagnosis hours, days, and even weeks before it can be achieved by those who rely solely on modern technology. And for some diagnoses (e.g., vascular headache, depression, irritable colon), there is no substitutive technology.

Plowing through this tome, learning what you can, and noting other passages for future use is hopefully part of your initiation into a very special and elite club. This club collects no dues and has no scheduled meetings (although you can attend a meeting any time you wish by picking up a book). It is founded on a certain value hierarchy, irrespective of dramatic changes in technology, and exists in the dimension of time, mostly irrespective of place.

The tradition of clinical examination dates back 2,500 years or earlier. The author of this book, who is attempting to help train you, was trained by Dr Jack Myers, who was trained by Dr Soma Weiss. With sufficient scholarly effort, it would be possible to trace a lineage from any reader back to Laënnec or even to Hippocrates.

We owe a great debt to those who taught us. The only way to repay the debt is to transmit the knowledge to the next generation, insofar as it is possible. In every hospital and every school that I visit, I meet young persons of the prerevolutionary type. This book is for them.

—Joseph D. Sapira, M.D., 1989

[1] Chargaff, working independently from completely different observations, also selects 1968 as the year of revolution. (See Chargaff E. *Heraclitean Fire: Sketches from a Life Before Nature*. New York: Rockefeller University Press; 1978.)

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I am deeply indebted to Dr Sapira for inviting me to help with the first edition of this book.

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CHAPTER 1

Introduction

If you would converse with me, you must first define your terms.
—VOLTAIRE

POINTS TO REMEMBER:

- As the library at Alexandria grew one volume at a time, your repertory will grow one fact and one skill at a time. Each must be reinforced and practiced.
- While digital computers use binary (yes/no, on/off) logic, the input from a clinical examination is characterized by varying degrees of uncertainty.
- In determining the predictive value of a test, the prevalence of disease in a given population is a critical and often forgotten factor.
- The sensitivity, specificity, and positive and negative predictive values of a test depend on the cutoff chosen for "normality." Changing the cutoff point decreases one type of error while increasing the other type.
- Accurate problem setting (or question framing) is essential to effective problem solving. Expertise in problem setting is the mark of master clinician.

How to Use This Book

This book is written for clinicians of differing levels of experience, from medical students in their first class in physical diagnosis to attending physicians of long experience. Many sections are designated for the more advanced reader. The presence of more difficult material should suggest to the beginning student that there is more to physical diagnosis than that tiny piece he[1] is able to assimilate at the beginning of his studies. Neither physical diagnosis nor clinical diagnosis can be learned in a week, a month, or even a year. How long does it take to learn clinical diagnosis? I[2] am still learning after 30 years. According to Tinsley Harrison, Friedman of Alabama was the best diagnostician he knew, and Friedman was still learning (and teaching) pearls when he was more than 70 years old. The best diagnostician I ever knew, Jack Myers of Pennsylvania, was, at the age of 70, entering his second decade of trying to teach a computer to think the way he did. On the other hand, I have had to tell some 24-year-old medical students that they were too old to become physicians because they had already lost their curiosity.

This textbook is intended for physicians, not for subspecialist technicians. Thus, the interviewing chapter is meant to apply to medical patients, not psychiatric patients. It is necessary to emphasize this point because of the present tendency, derived from the evolution of specialty medicine, to teach an abbreviated form of interviewing. And beneath the specialist stands the subspecialist, who may only need to diagnose four or five diseases, and so does not require much of a database from which to construct his history. Furthermore, an interview may not be considered necessary for building a relationship if the contact with the patient is to be episodic or even singular. In this increasingly prevalent situation, the whole patient has become less than the sum of his parts.

The early chapters on physical diagnosis introduce concepts in clinical reasoning that are reinforced throughout the book; they are not intended to be exhaustively descriptive. The scientific method is implicitly reviewed in the section on vital signs, wherein some small group self-experiments are described. By the time one has reached the examination of the heart, one will be reading long passages of physiology, pathophysiology, and hortative instruction.

Many of the advanced maneuvers would not belong in a routine physical examination. However, in order to learn "how to do it," the student needs to perform a certain number of such special examinations in normal subjects. Just what constitutes an acceptable number as well as which special maneuvers ought to become routine in a given population are questions whose answers are left to the discretion of a wise preceptor.

In many sections, I describe "a method" that I have used, taught, and found to be successful. These methods are not necessarily encyclopedic. For instance, I once wrote an article on physical examination of the spleen (Sapira, 1981a), which included a review of the world's literature and more different methods than could possibly interest any reasonable person. Although the article was published in an obscure state journal, within 2 months I was informed at the lunch table by three different persons, each of whom preferred a favorite but unique method, of all that had been left out of my article.

Throughout this work, certain "pearls" are indicated by a [ ] in the margin. Their selection is based upon the author's decades of clinical teaching. Some of them may not be pearls for you, whereas other statements might be so. You are encouraged to mark your own pearls.

[1] Use of masculine pronouns throughout this book is meant to include the feminine counterparts when not referring to a specific person. This is done for simplicity and is not intended to be discriminatory or exclusionary. In technical grammatical terms, the pronouns "he," "him," and "his" are either of the masculine or common gender, or in computer terms they are the default option for the third person singular personal pronoun when gender is unspecified.

[2] In the second and later editions, the first person singular pronoun "I" still refers to Dr Sapira. "This author" refers to Dr Orient.

Finally, there are marginal flags [ ] to indicate certain situations indicative of a real or impending emergency, wherein the beginner should immediately seek experienced aid for the patient.

To afford some respite from the prose, and to give the reader a chance to entertain one's speculative powers, amidst so much concrete instruction, some *objets d'art* are interspersed. These figures (some of which have been doctored) serve as illustrations of phenomena that were not photographed when I encountered them clinically. In addition, they illustrate the point that one is always a physician, even at the art museum, and that medicine is a learned profession that exists within the context of Western civilization.

The beginning student should not attempt to master everything on the first reading. The text is designed to permit you to reread the introductory passages, and, when you have mastered those, to go on to the complex material. In this way, the book and your experience can be concordant. Do not expect to understand much of the material until you have seen it demonstrated in real patients (e.g., if you are seeing many patients with pulmonary disease, but no orthopedic patients, initially, concentrate your attention on the chest examination and merely skim the sections that have to do with the bones and the joints).

Dr Rene Wegria of Missouri offers an interesting study technique especially suitable for passages that do not have numbers or statements to be memorized, but rather interconnected ideas. Read a paragraph and then close the text and repeat the paragraph back to yourself in your own words, not those of the author. Then reread the paragraph to be sure you understood it. If you cannot paraphrase the passage correctly, read it again and repeat the procedure. Do not go on to the next paragraph until you have mastered the first one.

It is important for you to be an active, not a passive, reader. To help in this regard, there are various quizzes throughout the book, or sometimes simply questions. As soon as you come to a question, attempt to answer it, and write down your answer. Too many students and "educators" alike act as if learning were a passive act. It is not like getting a suntan. You cannot simply show up and wait for it to happen! On the rare occasion when an answer to the quiz is not given, the author means to imply that just attempting to solve the problem should make the answer apparent.

Even better than reading actively is to *teach* the material, out loud, to imaginary students. It has been said that one remembers 14% of what one hears, 22% of what one sees *and* hears, and 91% of what one teaches others (Jones, 1990). The technique is recommended by a widely used home school curriculum (Robinson, 1997) and has been used with remarkable success by students who were mostly self-taught, even in learning very difficult scientific material.

For the Junior Student. The mind grows slowly, one skill or fact at a time. Therefore, you are encouraged to read about each patient seen every day and to try to learn at least one new fact about that patient and his disease. Similarly, you may wish to introduce one new maneuver a day from this book.

The greatest library known to the ancients, and possibly the greatest library of all time, was the one at Alexandria. It was built by requiring that no ship could dock in the harbor unless it brought payment of a book. Thus, the library was built one book at a time.

Unfortunately, the library at Alexandria was burnt in a tumult. The one at Constantinople was also burnt, but only so that the manuscripts could be used to heat the water for the public baths. It is said to have taken weeks to consume that library.

The mark of degenerate societies is that they foolishly consume the accumulated wisdom of their predecessors. So, too, is the accumulated wisdom of the clinician consumed by time and senility. Like the library at Constantinople, the only evidence of a former vigor may be the length of time it takes to burn out.

For the Attending. One curriculum is to have the students begin the interviewing course by taking the chief complaint the first week. The physical diagnosis course begins concurrently, with the students determining the vital signs of the same patient. The first case record consists only of the chief complaint and the vital signs, and whatever differential diagnosis that the students can develop. Each week, a portion of the history and the physical are added. For instance, in the second week, the students are asked to compose a history of the present illness (in addition to the chief complaint) and to record the general appearance as well as the vital signs. The next week, the integument is added, and the following week, the lymph nodes. By then, the students may be comfortable with the concepts involved in the history of the present illness and may begin adding the other portions of the history.

This system slows down the bright students, and the class does not get to the examination of the heart until half the course has passed. Also, the course is very expensive in terms of faculty time. The advantage is that any student of reasonable intelligence can be taught to do a thorough history and physical and to construct a differential diagnosis.

A Disclaimer

It is assumed that students will learn interviewing and physical examination by practicing on adults before venturing to see special populations including pediatric and obstetric patients. Growth and development from infancy through puberty, and the progress of a pregnancy, are fields in themselves. Students will need textbooks of pediatrics and obstetrics and will probably also want to obtain tables of normal vital signs, head circumferences, growth curves, and developmental milestones in small books that will fit in a pocket, black bag, or desk drawer. This book will include certain pathologic findings as manifested in pediatric or pregnant patients. The well-baby and prenatal examinations, however, are beyond the scope of this book.

Diagnostic Equipment to Purchase

The Sphygmomanometer

Be sure that the blood pressure cuff that you purchase is sufficiently long; you will also eventually need an extra wide one for accurate measurement of blood pressure in large arms (see Chapter 6). If you purchase an aneroid pressure gauge, which is less expensive than the now-endangered mercury manometer, be sure that it does not have a pin stop. Calibrate it according to the method in Chapter 6.

The Ophthalmoscope

These are the minimum *requirements* for a satisfactory ophthalmoscope:

1. An on–off switch (a rheostat is unnecessary)
2. A circle of light (you do not *need* the other apertures, although they are fun and may sometimes be helpful)
3. A focusing wheel

Additionally, you may be wise to purchase an instrument whose handle will also take the otoscope head to avoid buying two separate power sources.

If you have astigmatism, you may prefer to examine patients while wearing your glasses. If so, purchase an ophthalmoscope with a rubber cushion on the facing, so that it will not scratch your lenses.

See Chapter 10 for a discussion of the optional features on ophthalmoscopes.

Tuning Forks

I prefer to use a 1,024- or 512-Hz tuning fork for the Rinne and Weber tests (see Chapter 11) because high-frequency sounds are often the first ones lost in sensorineural defects, which are the hardest to detect. For testing vibratory sensation, the 256- or 128-Hz tuning fork is suggested (see Chapter 26).

Any tuning fork needs to have a sturdy handle with a base broad enough to ensure good contact with the bony prominences, along with tines that are weighted or sufficiently supple to vibrate for a reasonable period of time. Many of the free tuning forks that medical students receive from drug companies are worth what the students pay for them.

The Stethoscope

In 1821, R.T.H. Laennec (*The Treatise on Mediated Auscultation*, Vol. 1) wrote the following:

> I was consulted in 1816 by a young woman who presented some general symptoms of disease of the heart, in whose case the application of the hand and percussion gave but slight indications, on account of her corpulency. On account of the age and sex of the patient, the common modes of exploration being inapplicable, I was led to recollect a well-known acoustic phenomenon, namely, if the ear is applied to one extremity of a beam, a person can, very distinctly, hear the scratching of a pin at the other end. I imagined this property of bodies might be made use of in the present case. I took a quire of paper which I rolled together as closely as possible, and applied one end to the precordial region; by placing my ear at the other end, I was agreeably surprised at hearing the pulsation of the heart much more clearly and distinctly than I had ever been able to do by the immediate application of the ear.

The student should purchase a stethoscope with two different heads: a flat diaphragm, useful for picking up high-pitched sounds, and a bell, which, when softly applied, is better for detecting low-pitched sounds. Some bells have a rubber rim, which helps prevent the examiner from pressing so hard as to convert the bell into a diaphragm by tightening the skin beneath it. It is also useful for auscultating skinny, bony chests, as it is capable of forming a seal, which cannot be achieved with a metal-rimmed bell. You should be able to switch from one head to the other quickly and easily.

The length of the tubing is usually 12 in. or more. It has been scientifically proved that the shorter the tubing, the better (Rappaport and Sprague, 1941); but for tubing less than 12 in., what one loses in comfort (and consequently in the ability to concentrate) is offset by the gain in proximity. The very long-tubed stethoscopes (rarely seen nowadays) date from an era when the physician wished to keep as great a distance as possible between himself and a potentially infectious tubercular patient.

The most important criterion for the earpieces is that they be comfortable in your ears. Under no circumstances should you ever purchase a stethoscope with uncomfortable earpieces. Most medical supply houses will have sets of interchangeable earpieces so that one can get a comfortable set. (You might also find that you can hear much better with one style of earpiece.) Also check to be sure that the earpieces are slanted forward in approximately the same vectors as your external ear canals; some are slanted more than others. Because you will keep your first stethoscope for about 20 years, choose it with care, and do not buy it with the expectation that you will "adjust to it."

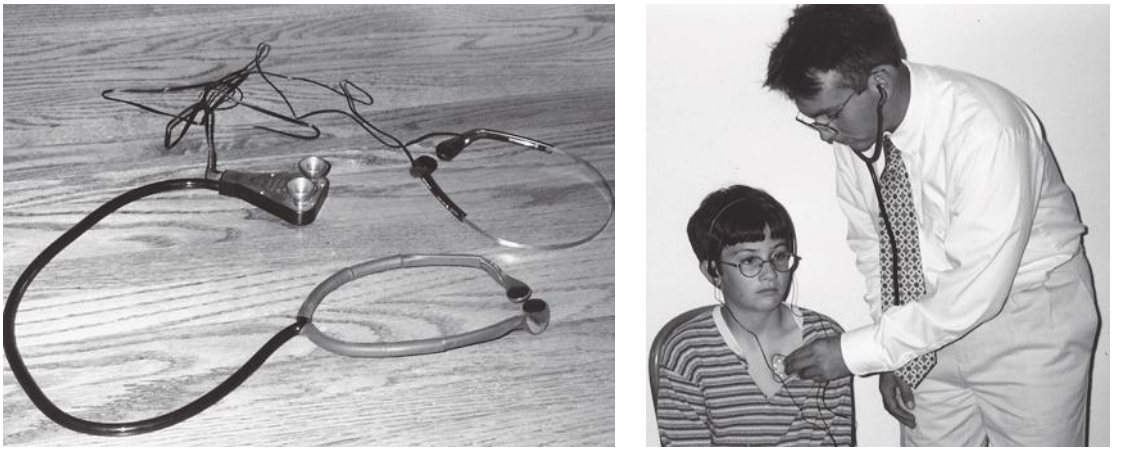
If you wish to compare the acoustic properties of two stethoscopes, the following method will detect gross differences without the use of fancy equipment: Place an earpiece of one stethoscope into your left ear, and place an earpiece of the second stethoscope into your right ear. Place the diaphragms of both stethoscopes on a solid surface, equidistant from a point 2 or 3 ft in front of you. Tap on the point, and in the manner of someone adjusting stereo speakers, notice whether the sound is louder in one ear than the other. To control for the possibility that your hearing is better in one ear, switch the earpieces and repeat the experiment. If the louder sound is now in the opposite ear, you have identified the stethoscope that is better for you. If you have an extra pair of hands, you might want to try this experiment with the unattached earpiece of each stethoscope occluded by a finger.

Question: What is the most important part of the stethoscope? (Appendix 1.1)

Amplifying stethoscopes are available. One study (Lukin et al., 1996) showed a significantly better detection of low-frequency sounds with an electronic stethoscope containing a sound amplifier and noise-filtering system (Medmax2) and suggested that such stethoscopes might have a role in bedside practice. One use of an electronic stethoscope is that the patient or a mentor may listen at the same time (Fig. 1-1). Note that the frequency distribution of sounds may be different from what is expected in the standard stethoscope. Always keep in mind the answer to the question above.

Clean the earpiece of your stethoscope from time to time with a cotton-tipped swab soaked in alcohol. A pipe cleaner might help clean out earwax that has migrated beyond the part that fits in the ear. Persons who produce copious quantities of earwax have on occasion noted it to be appearing at the chest piece. In former days, cardiologists regularly used compressed air to clean their stethoscopes.

Also clean the diaphragm of your stethoscope with isopropyl alcohol. Stethoscopes do harbor potential pathogens, especially on earpieces and diaphragm (Brook, 1997), and could be a source of nosocomial infections. Eighty percent of a sample of



A B

Figure 1-1 One use of the electronic stethoscope **(A)** is to permit the patient or student to listen at the same time as the physician or mentor **(B)**.

200 stethoscopes were found to be contaminated; four harbored methicillin-resistant *Staphylococcus aureus* (Smith et al., 1996). Bacterial counts were significantly reduced with isopropyl alcohol, but not with soap and water (Breathnach et al., 1992; Marinella et al., 1997). In one study, cleaning of the stethoscope diaphragm immediately reduced bacterial count by 94% with alcohol swabs, 90% with nonionic detergent, and 75% with antiseptic soap (Jones et al., 1995). With patients who require contact precautions, dedicated stethoscopes left at the patient's bedside are recommended (Wurtz and Weinstein, 1998).

Reflex Hammers

Purchase any kind of reflex hammer that you wish to. The most popular type, currently, is the Taylor hammer, whose head is a rubber triangle (see Fig. 26-24). This is a good hammer for beginners because it has both a point (which is optimal for circumstances in which even the beginner knows the exact spot to be struck, such as the biceps tendon) and a broad surface (which can bolster one's confidence when examining the ankle jerk). The head is usually mounted on a steel handle that ends in a point and may be used for producing a noxious stimulus (e.g., for the Babinski reflex) (see Chapter 26).

The Queen's Square hammer (see Fig. 26-26) is popular in England. It has a round rubber ring for striking, mounted on a long wooden handle whose sharpened end can be used for producing noxious stimuli (e.g., for waking medical students during lectures).

My original reflex hammer from medical school was simply a round rubber ball about the diameter of a nickel, mounted on a handle. This illustrates the point that any hammer is satisfactory if the examiner knows where to strike the tendon. I have even used the diaphragm of a Sprague stethoscope, and a former resident, a Vanderbilt graduate, used her knuckle. Some physicians use the tips of their fingers, a tool that is always available.

Other Equipment

It is helpful to have a spring-loaded tape measure, calibrated in both inches and centimeters. It is cheaper to buy one from a fabric store than from a medical supply store.

Do not buy a single pin to use for sensory testing. Chopsticks and a pencil sharpener or a fresh safety pin for each patient may be used for this purpose (see Chapter 26). Or you can break a wooden swab in half and use the pointed end. Hollow needles are too sharp; they cause bleeding. For testing light touch, you need a supply of cotton-tipped swabs. For testing two-point discrimination, you may want to purchase an instrument called a Disk-Criminator, with blunt metal points various distances apart.

Calipers for measuring lymph nodes and other swellings are described in Chapter 8. A goniometer for measuring range of motion, which may be purchased or improvised, is described in Chapter 25.

Space-age Equipment

For those who think that low-tech equipment is obsolete in today's high-tech society, the equipment used to monitor astronauts for the effects of microgravity includes: a penlight, a sphygmomanometer, an ophthalmoscope, an otoscope with disposable earpieces, a tuning fork, disposable tongue blades, a stethoscope, a neurologic pinwheel, cotton, a reflex hammer, and appropriate restraints (Harris et al., 1997).

The Science of Clinical Examination

Clinical diagnosis is currently the most neglected of the bases for the scientific practice of medicine. Yet, unlike the secondhand information with which the clinician often works, the clinical examination provides information obtained firsthand from the patient. Working with the primary source introduces in an almost effortless fashion the issues of level of certainty, normal variability, interrater reliability, intrarater reliability, and that unique, almost unconscious type of factor analysis used by the expert diagnostician. Experience with the clinical examination thus refines the techniques for handling information in general, and it develops the faculty for critical analysis that marks the scientist.

Unfortunately, the teaching of clinical examination is often marred by Olympian pronouncements sans references for specific statements. Providing references in areas that should be controversial

is one of the unique features of this book. Specific articles may be cited in the text where appropriate, and they will be listed at the end of a section or chapter. Where no article is mentioned, I have sometimes named the individual who taught me the sign. Unreferenced statements are usually based on the clinical experience of the author. (Clinical experience has been defined as "making the same mistake with increasing confidence for an impressive number of years," in contrast to "evidence-based medicine" [*vide infra*], which involves "perpetuating other people's mistakes instead of your own" [*Lancet*, 1997].)

General references are critically reviewed in the annotated bibliography in the last chapter. Though not without faults, these books, which might be called "golden oldies," have been helpful to me over the past 30 years, and the statements that I quote have been personally tested.

At bedside rounds at the University of Pittsburgh in the 1960s, Dr Eugene D. Robin always asked for the evidence for the data. His retinue of students and house officers felt that these carefully knotted strings of questions were but a requisite evil to be endured in passage to the nirvana of his 13 nostrums for the treatment of patients with chronic obstructive lung disease. Because there was a reason for each of the treatment orders (tea, supersaturated potassium iodide solution, ephedrine, etc.), it was clear to us that they were engraved on stone and would never change.

None of these nostrums are now used in the treatment of chronic obstructive lung disease, and atropine (which was then forbidden) is enjoying a renewed popularity. But the habit of asking "What is the evidence?" remains current.

The Art of Clinical Examination

Because clinical examination remains a personal activity, historical and anecdotal approaches have a place, and many items in this text are based on experiences that actually occurred during bedside rounds. The occasional use of the first-person singular pronoun may be disturbing to some readers who are accustomed to the impersonal tone of most contemporary texts. The impersonal tone is an implication of universality, implying that the author, like the physicist, has embarked on the discovery of truly universal truths. Alas, there are not many universal truths in medicine, and when there are—when something becomes 100% perfect—that something usually moves into the field of public health or is assigned to a physician extender. On the other hand, the personal pronoun is a statement of limitation, nonuniversality, probability, and conditionality. This is not egotism, but the exact opposite: the plaint of Hippocrates about the difficulty of learning the art, the perils of secure prognosis in our *techne* (a Greek word meaning science, art, profession, and career, all wrapped up into one).

The use of the personal pronoun is also an exhortation to the student. A student who has made carefully controlled observations in an area where no others have done so not only makes a contribution to the body of knowledge but also shows that he has learned, at an early stage, the levers by which corrigible minds are moved. Such a student has learned the intellectual ground rules of science, the laws of scientific evidence, by which he can stand on the shoulders of his elders. But his observations are still quite personal. They are limited by the environment and circumstances in which they were collected. Another time and place might yield different results to some other person. Thus, the personal pronoun is meant as a reminder of limitation, not as a banner of grandiosity.

Additionally, the personal pronoun is a reminder of the individual responsibility borne by the physician. Despite the proliferation of committees, responsibility must, by nature, devolve upon the individual. It is fitting that observations dependent on a human observer—always a particular human observer—must be signed, unlike the graph of temperature readings. The same is true for the physician's orders.

An individual may err or even dissemble; but the day that he relinquishes his individual authority and responsibility to an exterior authority is the day he renounces reason and conscience and opens the door to rampant error, pervasive deception, and the destruction of medicine as a profession (Read, 1949).

Ethical Foundations

The Oath of Hippocrates

Often referred to but seldom quoted, the Oath of Hippocrates embodies the assumptions underlying traditional medical ethics. The Oath reads

> I swear by Apollo the physician, by Aesculapius, Hygeia, and Panacea, and I take to witness all the gods, all the goddesses, to keep according to my ability and judgment the following oath:
>
> To consider dear to me as my parents him who taught me this art; to live in common with him and if necessary to share my goods with him; to look upon his children as my own brothers, to teach them this art if they so desire without fee or written promise; to impart to my sons and the sons of the master who taught me and to the disciples who have enrolled themselves and have agreed to the rules of the profession, but to these alone, the precepts and the instruction. I will prescribe regimen for the good of my patients according to my ability and my judgment and never do harm to anyone. To please no one will I prescribe a deadly drug, nor give advice which may cause his death. Nor will I give a woman a pessary to procure abortion. But I will preserve the purity of my life and my art. I will not cut for stone, even for patients in whom the disease is manifest; I will leave this operation to be performed by specialists in this art. In every house where I come I will enter only for the good of my patients, keeping myself far from all intentional ill-doing and all seduction, and especially from the pleasures of love with women or with men, be they free or slaves. All that may come to my knowledge in the exercise of my profession or outside of my profession or in daily commerce with men, which ought not to be spread abroad, I will keep secret and never reveal. If I keep this oath faithfully, may I enjoy my life and practice my art, respected by all men and in all times; but if I swerve from it or violate it, may the reverse be my lot.

Modern Ethics

In modern times, a revolution in ethical thinking is reflected in the various oaths and declarations that many institutions have proposed to supplant the "archaic" Oath of Hippocrates, beginning as early as 1948 with the Declaration of Geneva (Orient, 1994). The underlying assumptions are radically different.

In the Hippocratic tradition, ethics is founded on discoverable but unalterable universal law. The physician is responsible to each individual patient—and to the Lawgiver. The new ethics, in contrast, is based on man-made or *positive* law, and the needs and goals of individuals are subservient to those of society. Population health takes priority, raising the question of "Who is the patient?" (Jonsen, 1990).

The utilitarian concept of doing the "greatest good for the greatest number"—with Society or Humanity or even the Planet as the patient—is in irreconcilable conflict with the Hippocratic tradition of dedication to the individual patient (Baker et al., 1999). The Oath of Hippocrates is compatible with the Judeo–Christian ethic, the belief that humankind has inherent flaws, and the view that government should be constitutionally limited (Orient, 1981), and is incompatible with totalitarianism. The Oath of Hippocrates was in fact outlawed in the Soviet Union because it might have interfered with the physician's loyalty to the state (Field, 1957). Utilitarian modernist codes are compatible with an expansive, even totalitarian state, and reflect the utopian view that humankind is perfectible.

The *medical ethics* of "prehistory"—prior to about 1947—is being supplanted by *bioethics* (Irving, 2002). Moral absolutes are swept aside in favor of rules and mathematical risk–benefit ratios. Behavior directly forbidden by the Oath of Hippocrates is now defined as ethical, especially when it involves nonpersons or those deemed to be "nonsentient" or otherwise unworthy of life. Replacing the firm, immutable, timeless principles derived from natural law is a dialectic of internally contradictory demands (Arnett, 2002): the primacy of patient welfare, patient autonomy, and social justice. These are the three fundamental principles of the Charter on Medical Professionalism, put forth in response to "unprecedented challenges" of the new millennium, and "intended to be applicable to different cultures and political systems" (Medical Professionalism Project, 2002).

Discussion of the raging ethical conflicts that the American medical student will unavoidably confront is beyond the scope of this book. The reader should be aware, however, of the implications of the Hippocratic assumptions made by this author: the physician's calling is to serve each patient. An illness is important if it affects the patient, even if rare or politically disfavored. The physician's purpose is not to classify patients into categories defined by numerical codes, to calculate quality-adjusted worthiness to live, to determine the allocation of a common pool of "resources," or to achieve bureaucratically determined societal goals and objectives.

Definitions

Semantics has a profound effect on our thinking (Sapira, 1980a, 1981a, 1982). Conversely, the way in which I will use certain terms reflects the philosophy that underlies the approach to interviewing and diagnosis that will be taught in this book. The terms are listed alphabetically to facilitate future reference, but should be skimmed now for purposes of orientation. Mathematical terms related to the analysis of diagnostic tests are defined later in this chapter.

Academic medicine: That practice of medicine in which the practitioner is mainly concerned with the development of new knowledge.

Basic science: The parochially impractical but clinically useful sciences concerned with discipline-bound language and the general rules of scientific evidence.

Compliance: (i) change in volume per unit change in pressure (dV/dP)—a measure of the ease with which a structure may be deformed; (ii) a tendency to give in to others; (iii) obedience to a dictate given by an authority; (iv) (vulgar medical parlance) doing what the doctor wants.

The issue of "compliance" was "discovered" in the 1960s, and a professional discourse was created around this subject in the 1970s by Sackett and Haynes. Thousands of studies have sought to identify causes and design "corrective" interventions on the basis of the assumption that in the age of "evidence-based medicine" (*vide infra*), patients always ought to follow their doctor's orders and that those who do not are "deviant" (Lerner, 1997).

I have never had a patient who was completely noncompliant. As a rule, the bones are noncompliant, but the muscles and subcutaneous tissues are almost always compliant (myositis ossificans and calcinosis being the exceptions that prove the rule). I have had a number of patients who chose not to follow my advice. It is quite likely that the problem was with me, not with the patient. I had failed to spend enough time to persuade the patient of the presumed wisdom of my advice; or perhaps I had not got to know the patient well enough to understand why the advice would not be attractive. That failure on my part does not justify appropriating a word from the physical sciences to hide behind while blaming the patient.

These days, government and third parties demand that physicians and institutions be in "compliance" with volumes of regulations; "noncompliance" may be the cause for punitive sanctions. When the term "compliance" is used, it denotes that the subject is in a subordinate position and is very likely to have signed an agreement in which he is called a "provider."

Conversion: (i) To turn all together: as in, "the patient with atrial fibrillation and a high degree of atrioventricular dissociation underwent direct current conversion to normal sinus rhythm"; (ii) certain neurologic events of psychogenic origin such as paralyses and somatosensory impairments. The Freudian belief is that the unconscious conflict would be unbearable if it became conscious, so instead it manifests itself symbolically in a conversion reaction. (This is a glib summary of a very large body of work that I find quite convincing.)

Delivery system: Something that connects "providers" with "consumers" (Orvell, 1995). Examples include vending machines, Federal Express, and managed-care companies. "Health care delivery" is to be distinguished from the practice of medicine by physicians.

Diagnosis: (i) The process of identifying the patient's disease; (ii) a thorough understanding.

Disease: A particular destructive process or morbid change in an organism with a specific cause and characteristic manifestations; see *Illness*.

Education: Teaching the selection of contexts within which acts are performed; see *Training*.

Empiric: Reliably based upon experience, even if not yet scientific in terms of being connected to a substrate of knowledge or concepts sufficient to permit the observation to be understood within the framework of a general scientific theory. Contrast with *expectant*.

Evidence-based medicine: A movement that "de-emphasizes intuition, unsystematic clinical experience, and pathophysiologic

rationale as sufficient grounds for clinical decision making and stresses the examination of evidence from clinical research." It focuses on research in the new field of "clinical epidemiology," which encompasses the study of the entire clinical process, including diagnosis and evaluation of medical services (Swartz, 2002). This concept is discussed at greater length below.

Expectant: Often confused with empiric, this adjective applied to a therapeutic endeavor is synonymous with "hopeful" or "anticipatory." However, there is no reliably predictable outcome based upon past experience.

Falsifiable hypothesis: A hypothesis susceptible to being proved wrong. (The "best" diagnoses are falsifiable, a principle derived from Popper's statement about scientific hypotheses [Sapira, 1980b], which was anticipated by Nietzsche in *Beyond Good and Evil*, 1,18: "It is certainly not the least charm of a theory that it is refutable."[3]) For further discussion, see Chapter 27.

Functional: A word used to cover the physician's ignorance. Like "stress" (*vide infra*), this word should preferably not be used.

Historian: The person who composes a history of events that have happened to someone else.

History: The physician's abstraction of certain facts developed in the course of the interview and arranged in a manner that facilitates diagnosis.

Illness: The totality of effects, predicaments, and repercussions of the disease, deformity, or circumstances affecting a patient directly or indirectly.

Internal medicine: (i) (*obsolete*) That nonsurgical medical specialty concerned with clinical diagnosis and scientific therapy. Previously a secondary-care consultant specialty, it experienced crisis by lysis in the late 1960s; (ii) (*contemporary*) a biopolitical consortium of balkanized tertiary nonsurgical subspecialties, which, oxymoronically, claim it to be a *primary care specialty*.

Interview: The process of talking with the patient; see *History*.

Malingering: Pretending to have signs and symptoms that do not in fact exist. This is always a tenuous and sometimes a tendentious concept. It implies that the physician can know the thoughts of a patient who has chosen not to articulate those thoughts. Because the physician is not a mind reader, he must make an inference about what the patient is consciously thinking on the basis of the physician's knowledge of medicine and the signs and symptoms that are found.

Management: The process of directing a patient through an institutional protocol mandated for his condition without furthering one's understanding of his illness (*contemporary definition*).

Mutatis mutandis: *(Latin)* "Changing with change" (i.e., everything else changed accordingly).

Neurologic: Referring to all aspects of the nervous system and its examination except those having to do with affect, motivation, behavior, and the reporting of mental phenomena.

Objective: (i) (*non-Cartesian*) Capable of providing sufficient replicability to be used with a high degree of confidence; (ii) (*Cartesian*) observable by more than one reporter.

Organic: One of the languages in which patients can be described (Graham, 1967). If one thinks in terms of mind–body dualism, "organic" refers to the body. However, it is increasingly clear that events in the psyche have a biochemical manifestation. Because the term "organic" is hardly ever used correctly, it should be dropped from our vocabulary. Unfortunately, it is well-entrenched in misbegotten expressions such as "organic brain syndrome."

Physician: A professional who places his knowledge and skills at the service of a patient for making a diagnosis and healing or ameliorating illness. Physicians practice medicine, which is derived from the Latin root *medeor*, "to heal." They are not vendors who dispense services prescribed by an expert committee.

Practical: Capable of being perceived by the speaker as of immediate use in the solution of whatever problems can be identified by the speaker at that point in his intellectual development (*parochial*).

Provider: A person or entity that is contracted with and paid by a third party to perform certain services or supply certain products. Examples include durable medical equipment companies, nursing homes, chiropractors, therapists, and other persons licensed by the state to perform a health-related function.

Provisional diagnosis: Same as a conditional diagnosis—that is, a diagnosis suggested and favored but not yet proved. Provisional diagnoses are most useful when one has a simple test to refute them (disprove the hypothesis), but they are often diagnoses of common conditions for which no perfectly specific and sensitive laboratory test has yet been developed (e.g., essential hypertension). The provisional diagnosis is often elevated to "the" diagnosis by a process of elimination.

Psychiatric disease: A disease that at some time and place may be studied, diagnosed, or treated by a psychiatrist. (Notice that this definition tells you about nothing inherent in the ultimate nature of the disease.)

Psychogenic: *In strictu sensu*, caused by the psyche. This term should be used only on those rare occasions in which this mechanism has been clearly demonstrated. It should not be used as a synonym for "imaginary," "functional," or any other adjective used to cover the physician's own ignorance or uncertainty.

Psychosomatic: (i) Referring to the interaction between mental and physical levels of understanding; (ii) used to imply linearity or causality, especially on those occasions when it is used with the word "somatopsychic," as in: "the personality and behavior of some patients with hemophilia may be considered somatopsychic in origin and mechanism. But the explanation of certain of the episodes of activation of duodenal ulcer are more likely to be psychosomatic." (This statement predates the recognition of the role of *Helicobacter pylori*.) This word is often used incorrectly by the ignorant as a fancy synonym for "imaginary." In fact, there are no imaginary diseases except those afflicting imaginary animals. The term is also used incorrectly as a pejorative synonym for "psychogenic," especially when no positive evidence supports this putative mechanism.

Semeiophysiology: The study of the physiologic basis by which signs are produced (Sapira, 1981b); from the Greek *semeion*, meaning sign or signal.

Specialty: A practice that is restricted in some way.

Stress: The concept of stress was developed by Hans Selye, who defined it as the sum of all nonspecific biologic responses. Several aspects of this definition are noteworthy. First, as a clinician and diagnostician, one is most interested in specific responses,

[3] Nietzsche may thus be fulfilled in his own stated "ambition to say in ten sentences what everyone else says in a whole book."

rather than nonspecific ones. Second, stress was originally defined as a response, not a stimulus. At present, stress is colloquially referred to as if it were a stimulus, or what Selye called a "stressor." (A stressor was defined as any stimulus that would produce the stress response.) Lumping the stimulus and the response together has occasionally been a useful construct in medicine. For example, antigens and antibodies were once a tautology. Now it is possible to isolate antigens and antibodies and to determine their chemical structure. However, it is not possible to determine the specific structure of a concept such as stress. The third difficulty with the term stress is that the nonspecific biologic responses, summed, may actually be so variable as to make the word semantically useless. For instance, in an experiment in which swine were exsanguinated, the cortisol and epinephrine secretory rates increased in swine bled over 30 minutes, but not in swine bled over 80 minutes (Carey et al., 1976; Sapira, 1975). Should we conclude that bleeding to death slowly is not a stress, a stressor, or stressful? Finally, the best reason for not using the word stress comes from a semantic analysis of its use in medical services and in the medical literature. As currently used, the word obfuscates meaning, aborts communication, confounds data, distracts intelligence, and generally muddies the diagnostic water. Because the word is unnecessary and is inconsistently used, because it has no positive value that I have been able to determine, and because its many drawbacks are not balanced by any good feature, I feel it should be deleted—*stress delendam esse* (apologies to Cato).

Subjective: (i) (*non-Cartesian*) Incapable of consistently providing sufficient replication; (ii) (*Cartesian*) observable by only one observer; (iii) (current misusage) unconvincing and less true than "objective."

Test: A historic fact, a physical sign, or a laboratory procedure that has diagnostic value.

Training: Teaching the performance of specific acts irrespective of their logical context; see *Education*.

A Comment on Psychosomatic Medicine

For the Advanced Student. In this section, I have referred to Freud and to some of his influences on American psychosomatic medicine. In this view, problems began with conflicts in the psyche that mysteriously "leaped" into the soma. If one could resolve the nuclear conflict, one could prevent the pathogenetic "leap" to the soma, and the disease would get better. (Of course, this leap turned out to be more like a leap between parallel trails than like a leap across a chasm in one trail. Or to be specific, following Graham, it was a leap between two different languages used to describe two different aspects of the same patient [Graham, 1967]. Nevertheless, this philosophical point is not requisite to understanding the previous era's emphasis on interviewing medical patients about their inner [mental] lives and attempting to make some judgments based upon the premise that behavior is to a large extent determined by prior experiences.) In the course of spending time with the patient, as opposed to his laboratory tests and consultant reports, doctors did indeed note that patients improved. Some physicians were even able to perceive patterns that were not universally useful in a diagnostic sense, but that seemed to be statistically associated with diseases, and thus to tantalize with the promise of heuristic value. Although this approach required a great investment of time initially, the material developed was of more or less permanent value in understanding the patient. Unfortunately, the tendency in recent decades has been to emphasize activities with a guaranteed payoff and very little front-end loading. As a result, we have wondrous ways to image the patient's organs, but no commonly used way to understand why the patient with a certain genetic marker does or does not manifest disease at any particular time.

Evaluation of Diagnostic Signs: More Definitions

The habit of quantitative thinking is a hallmark of the scientist. The discipline of quantifying observations makes one a more careful observer. Furthermore, the physician who is not overawed by the mystique of objectivity that emanates from data expressed in three or more significant figures will not be betrayed by an uncritical dependence upon them. Moreover, if one understands certain definitions, one can avoid some common errors of inference.

For the Beginning Student. More detail is presented here than many physicians have encountered in all of their medical training. Take it one step at a time. Not all physicians will become adept in using the more advanced concepts; some formulas are presented for the sake of completeness, and to be available for future reference. It is important for all students eventually to grasp the potential and the limitations of the tools for diagnosis, and of the need for their constant reassessment and refinement.

Incidence and Prevalence

Many physicians use the word incidence when they mean prevalence. *Incidence* refers to events that occur during some period of time. For instance, "on a certain island, there are ten new cases of disease X each year." Incidence may also include the population denominator (e.g., 0.1 new cases per thousand per year). *Prevalence* is the prevailing rate of cases extant at any given point in time. For instance, "on the second anniversary of the arrival of the first case of disease X on the island, the prevalence of the disease was 20 per 100,000."

Question: *If all of the above statements came from the same source, and disease X is neither fatal nor curable, what was the population of the island in question*? (Appendix 1.2)

Sensitivity and Specificity

The *sensitivity* of a test is the fraction of people with a disease that have a positive test (Table 1.1 and Fig. 1-2). Formally, it is defined as the following ratio: true positives/(true positives + false negatives). This is also called the true-positive rate.

A test with high sensitivity is not necessarily a useful test. The sign "10 fingers" would be extremely sensitive for almost any disease because most patients with the disease will have ten fingers. Very few patients with the disease will have a different number of fingers. Thus, the ratio of true positives (number of patients with the disease who have ten fingers) to the sum of true positives plus false negatives (where false negatives are people who have the disease and do not have ten fingers) will usually be greater than 0.99 (except in a sanitarium for Hansen disease). Yet, common sense tells us that the possession of ten fingers, however sensitive on paper, is not of great use to the diagnostician. Why not? The reason is that

TABLE **1.1** *Definitions*

Disease present		Yes (D+)	No (D–)
Test positive	Yes (T+)	TP	FP
	No (T–)	FN	TN
Prevalence	= (TP + FN)/(TP + FN + FP + TN)		
Sensitivity (true-positive rate)	= TP/(TP + FN)		
Specificity (true-negative rate)	= TN/(TN + FP)		
Positive predictive value	= TP/(TP + FP)		
Negative predictive value	= TN/(TN + FN)		
False-negative rate	= 1 – sensitivity = FN/(TP + FN)		
False-positive rate	= 1 – specificity = FP/(TN + FP)		
Accuracy	= (TP + TN)/total		
Positive likelihood ratio (LR)	= sensitivity/(1 – specificity)		
Negative likelihood ratio (LR)	= (1 – sensitivity)/specificity		

TP, true positives; FP, false positives; TN, true negatives; FN, false negatives.

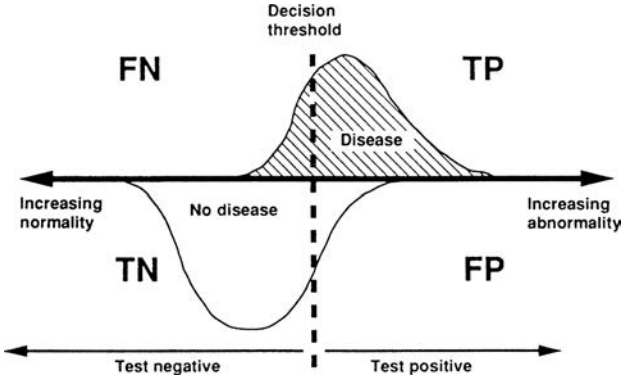


FIGURE 1-2 Graphical depiction of the terms used for describing and comparing diagnostic tests. Hatched area above the *x*-axis represents those affected by disease, and area below the *x*-axis represents those not affected. The decision threshold represents the cutoff point chosen to separate normal from abnormal. The areas within the curve and bounded by axes denote the true-positive (TP), false-positive (FP), true-negative (TN), and false-negative (FN) results. (From Brismar J, Jacobsson B. Definition of terms used to judge the efficacy of diagnostic tests: A graphical approach. *AJR.* 1990;155:621–623, with permission.)

most of the people in the world have ten fingers but do not have the disease.

As a rule, tests with low sensitivity are useful only if they have a very high specificity. Such tests would never be used for screening, but can help separate the true from the false-positive results after a prior, more sensitive test.

Specificity is mathematically defined as the true-negative rate, or true negatives/(true negatives + false positives)—that is, the proportion of people who do not have the disease and who also do not have a positive test.

A Self-study Question

Test A has a sensitivity of 100%, but a specificity of only 20% for disease X. Test B, which is very expensive, has a specificity of about 100%, but a sensitivity of 50%. How should one go about finding cases of disease X? Write down your solution. Take your time; this is a critical issue (Appendix 1.3).

A Caveat

When many clinicians use the term *specificity*, they have in mind the following ratio: true positives/(true positives + false positives) (i.e., the probability that a person with a positive test will have the disease, or the predictive value of a positive test or positive predictive value) (Table 1.1). In fact, specificity once was understood in that way. (*Stedman's Medical Dictionary*, 21st edition, 1966, defined specificity as "the state of having a fixed relationship to a single cause or to a definite result.") Note that *if* a test has a very high positive predictive value (i.e., very few false positives), it will also have a high specificity. But the converse of this statement is not necessarily true. In other words, a high specificity does not guarantee a high positive predictive value, as we shall see.

The clinician's tendency to translate mathematical specificity into a sense of the significance of a positive test is a hazardous pitfall. A mathematical specificity of 90% sounds very good, and the clinician might think that a positive result is very reliable. But in reality, the likelihood of a false positive might be quite high, as the next example shows, because the predictive value of a test is highly dependent upon the prevalence of disease.

To avoid misunderstanding, in this text, the term *pathognomonic* is used to refer to a sign with a very high positive predictive value, although other texts or journal articles might call such a sign "highly specific." The word is derived from the Greek *pathos*, meaning disease, and the Greek *gnomonikos*, meaning capable of making a judgment. The term diagnosticity is generally used in this text to mean the predictive value of a positive test.

Example

To understand the definitions in Table 1.1, you must work an example and must fill in a 2 × 2 table like Table 1.1 yourself. Consider a sign that is 100% sensitive and 90% specific. (The 90% specificity means that there are only 10% false positives—that sounds good, wouldn't you agree?) The sensitivity and specificity were derived from filling in a 2 × 2 table for a test population, which is probably very different from the general population, having been selected to include a lot of patients with the disease being tested for. You now want to apply the results to the real world, to a population of, say, 100 patients, to judge whether the presence of the sign is of diagnostic value.

At this point, you do not know enough to write any numbers in your table. You only know that (TP + FN + FP + TN) = 100. The missing piece of information is prevalence. In your population, the prevalence of disease is estimated to be 9%. In that case, 9 patients will have the disease and 91 will not. Because the sensitivity of the test is conveniently 100%, all 9 of the patients with disease will have a positive test, so you can write a "9" in the TP box and a "0" in the FN box. Because the test is 90% specific, 90% of the 91 patients who do not have the disease, or 81.9, will have a negative test, and 9.1 will have a positive test. Thus, you can fill in the remaining boxes, and you can check that the numbers add to 100.

Now look at the patients who have a positive sign: 9 of them have the disease and a true-positive test, and 9.1 of them do not have the

disease but have a false-positive test, giving a total of 18.1 patients with a positive sign, out of the original population of 100. But only 9 of these 18.1 cases (49.7%) actually have a true positive. This is the positive predictive value, here quite weak, despite the high specificity.

For the Neophyte. Master clinicians know all of the above at an unconscious level, and hence seldom explicate it. Most students find these points difficult to understand at first. These crucial definitions will be reemphasized throughout this text in terms of illustrative findings. By the end of this book, you should be able to use these concepts with confidence. They are brought to your attention now because some of the findings described in this book are very important whenever you find them (because there are few false positives), whereas others become important only when they are absent (because they are highly sensitive, and their absence thus nearly excludes the disease). Obviously, if you are to have confidence in the application of these powerful concepts, you must become very accurate in your detection of the findings and must be equally confident of not "finding" them when they are not present.

In the example given above (a test of 100% sensitivity and 90% specificity applied to a population with 9% prevalence), the positive predictive value was so low that you would be slightly better off guessing that a patient with a positive test did not have the disease, a conclusion that may seem to be contrary to common sense. However, a positive test raises the probability of disease from 9% (*prior probability*) to 49.7% (*posterior probability*, i.e., the probability after the test). Unfortunately, this is the kind of result that makes skeptics laugh and exclaim that the test is about as good as flipping a coin. This last statement is not true because the majority of patients without disease will have a negative test. The 49.7% is a *conditional probability: If* the result is positive, the probability of disease is 49.7%. Furthermore, there is a chain of reasoning in clinical problem solving. The figure of 49.7% may now become the input (*the prior probability*) for the next test ordered. Sequential positive tests with a positive predictive value of about 50% would make the sequential probabilities 50%, 75%, 87.5%, 93.75%, and so forth, tending asymptotically toward 100%. Because questions can be asked quickly and also because physical maneuvers can be done quickly in sequence, many skillful physicians can thus come to a rapid diagnosis, even though the individual maneuvers may be likened to flipping a coin.

There is an even more important consideration. In the example above, the predictive value of a negative test or negative predictive value is excellent. In fact, it is an incredible 100% (because of the 100% sensitivity). In other words, the absence of the sign is a virtual guarantee of the absence of the disease (also see Chapter 27).

By way of a clinical example, consider heart murmurs in making or excluding a diagnosis of valvular heart disease. The absence of a systolic murmur is more important than its presence because systolic murmurs tend to have a high sensitivity (few false negatives) and a lower mathematical specificity (many false positives). On the other hand, the presence of a diastolic murmur is very helpful because there are few, if any, "innocent" (false positive) diastolic murmurs. Thus, the predictive value (and also the specificity) of diastolic murmurs is high.

For the Experienced Clinician. The tendency to confuse specificity with the positive predictive value may result from the fact that the clinician is considering signs and symptoms (as opposed to laboratory tests) as positive leads to the existence of disease. In contrast, laboratory tests, for which the concept of specificity was developed, have traditionally been used to exclude entities in the differential diagnosis. It is true that laboratory tests are more commonly used today to search for positive leads (or misused by the clinically inept). Such usage may produce what has been called "data in search of a hypothesis" (Greenberger, 1990), leading to increased costs and iatrogenic complications, as more invasive tests are employed to track down elusive causes of the false positive. However, if one keeps the original use of laboratory tests as definitive excluders in mind, the conceptual relationship of mathematical specificity (in a laboratory test) to the predictive value of a positive sign or symptom (in clinical examination) should be clear.

Although sensitivity and specificity have definite numerical values determined from a sample population, they are not constants. They are, in a sense, a trade-off. By changing the cutoff points for a "positive" and "negative" test, the sensitivity could be increased at the cost of a lower specificity, and vice versa. (See Chapter 10 for a discussion of α and β errors, which have a reciprocal relationship and depend upon the chosen cutoff points.)

The information content of a diagnostic test may be very low. Diagnostic tests published in the medical literature from 1982 through 1986 had a median information content of only 55% of that needed to reach diagnostic certainty. The original evaluation of the tests was often flawed, due to interobserver variation, random sampling errors, and the use of an inappropriate spectrum of disease severity and comorbidity. In any case, the amount of information that a test can provide inevitably depends upon how much is known about a patient's status before the test is performed (Heckerling, 1990). In other words, phenomenal improvements in diagnostic imaging and the clinical laboratory have by no means reduced the need for a competent interview and physical examination.

For the Guru. Specialists in disease Y study their *patients* to learn the sensitivities of tests C and D. An insurance company studies the specificities of tests C and D in insurance applicants (presumably healthy *controls* shown not to have the disease). If the prevalence of the disease is 50%, will the positive and negative predictive values of the tests be any different than if the prevalence of the disease is only 5%? When data appear in the literature, people often do not notice that they come from widely disparate populations, a fact that will greatly affect predictive value. As a general rule, studies of diagnostic tests tend to be performed in populations with high disease prevalences. Under these circumstances, the test's accuracy is unusually dependent on the sensitivity; positive predictive values are high and negative predictive values are low. However, in most clinical situations, disease prevalence is low, and the accuracy of these same tests becomes less dependent on sensitivity and more dependent on specificity; the positive predictive values are lower and the negative predictive values higher (Eisenberg, 1995).

A Perspective

Sensitivity and specificity are not universal constants. They are determined within a particular context, which may not be applicable to your patient population. When confounding factors and the interactions of various diseases enter in, the sensitivity and specificity are rough estimates at best. And remember that they depend on the cutoff points for defining "normality."

The impact of a test is generally greatest for midsized probabilities of disease (say between 20% and 80%). If a condition is either very rare or very common, only a very definitive test will change the probability much. But, even a moderately precise test will greatly change the posttest probability if the pretest probability is mid-range. Negative tests are often better at ruling a condition out than positive tests are at confirming it.

The Likelihood Ratio

Once mastered, the likelihood ratio (LR) is a faster and more powerful approach to describing the accuracy of diagnostic information and for determining the posttest probability of a target disease. The LR expresses the odds that a given (positive or negative) finding would occur in a patient with, as opposed to a patient without, the target disorder. The *positive LR* is the proportion of patients *with* the target disease who *have* a particular finding (the sensitivity) divided by the proportion of patients *without* the disease who have the same finding (the complement of the specificity, or [1 − specificity]). The *negative LR* is the proportion of patients *with* the target disease who *lack* a particular finding (1 − sensitivity) divided by the proportion of patients *without* the disease who lack the same finding (the specificity).

Signs with LRs greater than 1.0 increase the probability of disease; the higher the value, the more compelling the evidence *for* the disease. Signs with LRs between 0 and 1.0 decrease the probability of disease. The closer to zero, the more compelling the evidence *against* the disease. All LRs are mathematically positive. A "positive LR" describes how the probability changes when a sign is *present*. A "negative LR" describes how the probability changes when the sign is *absent*.

Using the nomogram shown in Fig. 1-3 obviates the necessity for converting pretest probability into odds, and odds back into a posttest probability, using the formulas in Table 1.1. LRs can be determined for various levels of test results, instead of the classification "normal" versus "abnormal" (Sackett, 1992; Sackett et al., 1991).

The nomogram can be used iteratively for a combination of signs that have a different semeiophysiology, the posterior probability for disease, given the first sign, becoming the prior probability in the next iteration.

A Self-study Question

A patient presents with acute fever and cough. The prior probability of pneumonia in such patients is 0.2. The patient also manifests an altered mental status (positive LR = 2.2) and diminished breath sounds (positive LR = 2.0). What is the posterior probability of pneumonia, given these signs? (Appendix 1.4)

An Alternate Definition

Some define the negative LR as the probability of no disease, given a negative test (Weissler, 1999), or specificity/(1−sensitivity). This is the inverse of the definition given above.

"Ruling In" or "Ruling Out" Disease

Very advanced. A rule of thumb on choosing a diagnostic test to "rule out" or "rule in" a specific disease has been summarized by the mnemonics SnOut and SpIn. The most sensitive test rules out a disease and should be used when the consequences of missing the disease are serious and the treatment is relatively safe. The most specific test rules in a disease and should be used when the cost of false-positive results is high. Boyko provides a mathematical proof that this is not necessarily the best strategy for revising disease probability. The LR is preferable because it reflects a test's ability to rule a disease in or out, regardless of the prevalence of the disease. In general, if two tests are considered to rule out disease, the more sensitive test will better achieve this *if* its specificity equals or exceeds that of the competing test, while if two tests are considered to rule in disease, the more specific test will better achieve this goal *if* its sensitivity equals or exceeds that of the competing test. If the goal is to achieve maximum clinical utility, and not just the best estimate of disease probability, the costs of treating patients with false positives or missing opportunities to treat patients with false negatives must also be considered (Boyko, 1994).

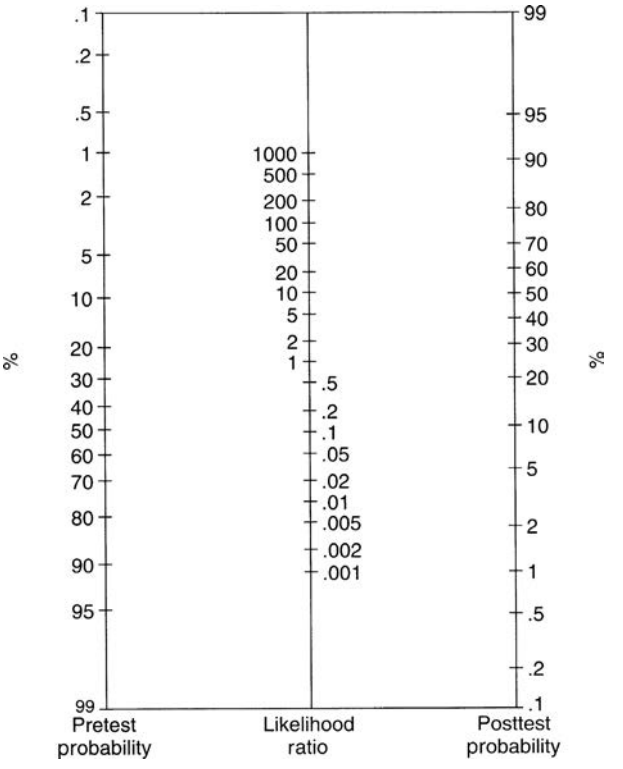


Figure 1-3 Nomogram for applying likelihood ratios. Connect the pretest probability and the likelihood ratio with a straight edge and extend the line to intersect with the posttest probability. Of course, for a likelihood ratio of 1.0, the pretest and posttest probabilities are always equal. (From Sackett DL. A primer on the precision and accuracy of the clinical examination. *JAMA*. 1992;267:2638–2644, with permission.)

Bayes Theorem

For the Aficionado. Bayes Theorem relates the conditional probability of disease, given a certain constellation of findings, to the prevalence of the disease and the probability of each finding, from studies of patients who had the disease. This is the theorem underlying the nomogram given in Fig. 1-3.

In generalized form, the theorem states

$$P(H|D) = P(D|H) \times P(H)/P(D) \qquad (1.1)$$

which means that the probability of the hypothesis, given the data, is equal to the probability of the data, given that the hypothesis is correct, multiplied by the probability of the hypothesis before obtaining the data divided by the averaged probability of the data (Malakoff, 1999).

The above is a simplification of the following:

$$\Pr(I_i|C_p) = \frac{P'_i \Pr(C_p|I_i)}{P'_i \Pr(C_p|I_i) + \sum_j P'_j \Pr(C_p|I_j)} \qquad (1.2)$$

where $\Pr(I_i \mid C_p)$ is the probability of illness I_i, given the clinical profile C_p of the patient; $\Pr(C_p \mid I_i)$ is the probability of clinical profile C_p, given the diagnosis of illness I_i; and the parameters P'_i and P'_j, for $j = 1, 2, \ldots$ are the prior probabilities of each of the respective illnesses that could account for the clinical profile, defined without regard to the clinical profile but only with respect to the "host" characteristics such as age and place of residence (Miettinen and Caro, 1994).

The theorem, which was developed by Presbyterian minister Thomas Bayes circa 1763, originally focused on predicting the behavior of billiard balls. It is now used theoretically in fields ranging from astrophysics to genomics, and practically in testing new drugs, setting public policy, and consumer products (e.g., in the algorithm that animates the whimsical paper clip in Microsoft Office software, which makes Bayesian guesses about what information the user is likely to need) (Malakoff, 1999).

There are a number of pitfalls in applying Bayesian analysis to medicine. The probabilities must be independent, an assumption that is seldom entirely correct. It is a challenge to identify the set of illnesses that need to be considered, the probabilities of which add up to unity within the clinically restricted set. For each illness, one must determine the prior probability: the expected proportion of people with that illness, at the time of diagnosis, among all people who share the patient's nonclinical profile and have one of the illnesses capable of explaining the constellation of findings. In practice, determining the required parameters represents "a generally insurmountable epistemologic challenge" (Miettinen and Caro, 1994). Moreover, the analysis of the same evidence leads to dramatically different results if one starts with different beliefs and experiences (Malakoff, 1999).

While those who construct algorithms and adhere strictly to "evidence-based practice" apply Bayesian analysis, few, if any, physicians actually use it. Algorithms may reliably distinguish strep throat from viral pharyngitis, but if the physician needs to think outside their boxes, if test results are inexact or symptoms are vague, multiple, or confusing, something besides a binary-logic framework is needed. Dr Jerome Groopman of Harvard Medical School is one professor recently undertaking the challenge of teaching how expert clinicians deal with situations of "uncertainty, instability, uniqueness, and value conflict"—in other words, "flesh-and-blood decision making." (Groopman, 2007) He begins with a quotation from William James: "We carve out order by leaving the disorderly parts out."

False Positives

In the older literature, the term *false-positive rate* has been used to mean the percentage of patients with positive tests who had a false-positive result [i.e., FP/(TP + FP)]. However, it has been undergoing an evolution similar to that of specificity, and in the decision-analysis literature (Hagen, 1995; Weinstein and Fineberg, 1980), it is defined as the frequency of positive test results in those without disease [i.e., FP/(TN + FP) or (1 − specificity)].

Normal

Sometimes normal can be defined dichotomously as the presence or absence of a sign. (Dichotomous means "cut in two.") However, many measurements are in terms of units that are numerically continuous, such as pounds, inches, milligrams per deciliter, and so forth. Often, if one plots a frequency distribution of these measures (for weight, height, serum uric acid, etc.), one obtains the famous bell-shaped curve of Gauss. This curve is unimodal; it has one hump (see the unimodal camel in Chapter 16). Doctors would prefer a bimodal distribution, so that one hump could be labeled "normal" and the other "abnormal." With the unimodal distribution, we are often faced with the problem of determining "how far is up?" At what point does the patient become too short, too tall, too fat, too skinny, or hyperuricemic? Whatever dichotomizing point we propose, the question could be asked: Why is 20 units abnormal, whereas 19.5 units is normal?

When a mortal argues with God about the number of just men required to spare a city (Rabbenu, 1200 BC), God can arbitrarily choose 10 (and thus instantly dichotomize the universe of cities). Scientists sometimes choose two standard deviations above or below the mean as the cutoff point for normality, but to take these points too seriously would be to engage in arbitrary godlike behavior.

In these days of multichannel machines for determining blood chemistries, it is especially important to remember the definition of "normal." The "greater than 1.96 standard deviations from the mean" criterion arbitrarily designates 5% of a normal population as "abnormal" (2.5% as "abnormally high" and 2.5% as "abnormally low"). This means that each test will be normal in only 19 out of 20 healthy subjects. The probability that all 20 tests will be normal is 0.95 to the 20th power (0.358), and the probability of one or more abnormal results is (1 − 0.358) = 0.642.

Actually, tests on the chemistry screen are not independent; the liver enzymes are correlated with each other, as are the blood urea nitrogen and creatinine, to name just two examples. Moreover, the assumption of a Gaussian or "normal" distribution is not necessarily correct. Analyses of urine from 1,000 newborn infants showed that some substances have bimodal or trimodal distributions; in fact, only about 40% had a unimodal distribution (A.B. Robinson, *personal communication*, 1995). Therefore, the situation is more complicated than this paragraph indicates.

When setting a cutoff point for "normality," the physician must always keep in mind that he is choosing the type of error that he prefers to make: false positives or false negatives (α or β errors, as shown in Fig. 10-26).

Accuracy

The calculated accuracy of a diagnostic test [(TP + TN)/(TP + FP + TN + FN)] may be quite misleading because of differences between the populations in which the test was studied versus the

clinical population in which it is applied. Moreover, the certainty of a test's predictive value depends on the number of observations on which it is based; for some tests, the standard population was very small. The 95% confidence interval for a predictive value is expressed as

$$p \pm 1.96\sqrt{p(1-p)/N} \quad (1.3)$$

where N is the number of subjects in the study group, and p is the prevalence of disease (Hagen, 1995).

Precision

To achieve accuracy, it is necessary (though not sufficient) for data to be precise (or reproducible), that is, it is necessary for two observers to agree on the presence or absence of the symptom or sign. The measure of agreement between observers is called kappa (κ) and is like a correlation coefficient. Kappa is equal to (observed agreement – expected agreement)/(1 – expected agreement). Values range from −1.0 (perfect disagreement) through 0 (the level of agreement expected by chance alone) to 1.0 (perfect agreement). For levels of κ between 0.0 and 0.2, the degree of agreement is said to be "slight"; between 0.2 and 0.4, "fair"; between 0.4 and 0.6, "moderate" between 0.6 and 0.8, "substantial"; and between 0.8 and 1.0, "almost perfect" (Sackett, 1992).

Evidence-based Medicine

> *But I shall let the little that I have learnt go forth into the day in order that someone better than I may guess the truth, and his work may prove and rebuke my error. At this I shall rejoice that I was yet a means whereby this truth has come to light.*
>
> —Albrecht Dürer, 1513

The concepts explained above are used in evidence-based medicine, which is now trendy enough to have an acronym, EBM, and an entry in the National Library of Medicine Medical Subject Headings. Exercises designed to hone the student's skills in interpreting the clinical findings in the light of EBM are sprinkled throughout the book. More comprehensive collections of data on various findings are now available (McGee, 2001).

More than 100 books and thousands of articles have been published on EBM. It has been subjected to major criticism, including the observation that it is not itself evidence based, in that there is no convincing evidence that physicians using it provide any better care than those who do not. Perhaps the most balanced definition is that EBM constitutes "methods of incorporating epidemiologic evidence into clinical practice" (Cohen et al., 2004).

Inputs—the GIGO (Garbage in/Garbage out) Phenomenon

Although the quantitative analysis of findings is important, some caveats are in order.

The numbers used in EBM calculations are necessarily quite imprecise. It is generally assumed, for example, that sensitivity and specificity are invariant with respect to the severity of disease. This is not true. Moreover, the preferential referral of patients for further testing, while clinically rational, distorts the observed sensitivity and specificity, as illustrated by an extreme example (Diamond, 1999):

> Suppose a diagnostic test has a sensitivity of 80% and a specificity of 80%. Suppose further that every patient with a positive test is referred for a procedure to verify the diagnosis and that no patients with negative tests are referred. Because only positive responders have the test confirmed, every detected diseased patient will have a positive test (sensitivity = 100%), but so will every nondiseased patient who is referred for the procedure (specificity = 0%).

Framing the Question

Even if one does all the mathematics correctly and enters reliable numbers, the answer may be invalid or inapplicable—say if one is attempting to answer the wrong question. The emphasis on problem solving may divert attention from problem setting, the process of determining the decisions to be made and the ends to be achieved.

> In real-world practice, problems do not present themselves to the practitioner as givens. They must be constructed from the materials of problematic situations that are puzzling, troubling, and uncertain. In order to convert a problematic situation to a problem, a practitioner…must make sense of an uncertain situation that initially makes no sense…. Problem setting is a process in which, interactively, we name the things to which we will attend and frame the context in which we will attend to them (Schön, 1995).

How Clinicians Think

Lectures on EBM in medical schools typically provide little insight into how expert clinicians actually think. The process of clinical reasoning, or synthesizing the data, is discussed in Chapter 27. Although the concepts there cannot be fully utilized without the material in the prior chapters, the student should skim Chapter 27 now to obtain a general idea of how a structure will eventually be built from the data. One needs both a plot plan and materials to construct a building; they are mutually dependent.

In describing their own methods of inquiry, clinicians speak of "experience, trial and error, intuition, and muddling through" (Paterson, 1997). In actuality, this process involves pattern-recognition skills too complex to be duplicated by a computer. It also involves the ability to cope with the 80% to 85% of clinical experiences that are "not in the book," using processes of "reflecting in action," often recognizing phenomena of which they cannot give a complete description (Schön, 1995).

What Is "Evidence"?

Although EBM is supposed to replace authority-based medicine, it may effectively just replace the clinical professor with a committee, which is vested with the authority to rule on what constitutes evidence—and what type of evidence gathering will be permitted and funded.

"Anecdotes" are out, even though as one wise professor observed, "every epidemic starts with a single case report" (R.L. Kimber, *personal communication*, 2000). Serendipitous breakthroughs are made by individuals who make careful observations of patients from

close range—seldom or never by a team encumbered by a rigid experimental protocol and the huge number of subjects needed to reach statistical significance.

Single observations may be extremely important, even if not statistically significant in the context of a large trial. Say, for example, a rare, otherwise unexplained event follows a medical intervention: a patient takes a drug and inexplicably goes blind. It might be a coincidence, or it might be a side effect of the drug. One cannot rule out a causal relationship based on lack of a statistically significant difference in this occurrence between the drug and placebo groups in a trial of insufficient power to detect a rare event. One is obligated to investigate further.

Students will be hearing much more about EBM in the context of treatment rather than diagnosis, but the data from the interview and physical examination will be inputs into treatment decisions. A key question that physicians should ask is whether the patient at hand is sufficiently like the subjects in the trial that will be cited as the rationale for treatment. A clinical trial with excellent internal validity may have poor generalizability (external validity) because the population of study patients may be overly constrained and nonrepresentative (Kocher and Zurakowski, 2004).

In EBM, the randomized controlled trial (RCT) is taken as the gold standard. Yet, RCTs have important limitations that make it unlikely that they will ever become the basis for most bedside medical decisions (Caplan, 2001).

RCTs are inevitably complex and extremely expensive. With a huge investment at stake, those who fund the studies are unlikely to be completely unbiased. Exposés of conflicts of interest have been published in prominent medical journals, including the *British Medical Journal* (Greenhalgh, 1997), *The Lancet* (Collier and Iheanacho, 2002), and the *New England Journal of Medicine* (Stelfox et al., 1998). Nevertheless, the quality of clinical trials has not necessarily improved (Kauffman, 2004).

Aside from funding issues, RCTs have inherent theoretical and practical pitfalls: the enrollment of suitable patients, the definition of appropriate outcomes, and consistency in measurements (Caplan, 2001). Some questions simply cannot be studied by an RCT: For example, "whether parachutes are effective in preventing major trauma related to gravitational challenge" (Smith and Pell, 2003). The authors of this commentary state:

> As with many interventions intended to prevent ill health, the effectiveness of parachutes has not been subjected to rigorous evaluation by using randomized controlled trials. Advocates of evidence-based medicine have criticized the adoption of interventions evaluated by using only observational data. We think that everyone might benefit if the most radical protagonists of evidence-based medicine organized and participated in a double blind, randomized, placebo-controlled, crossover trial of the parachute.

In a perspective invited by the American Academy of Neurology, whose guidelines are a very popular product, it is noted that "knowledge derived from evidence needs to be viewed as one pillar, not the sole pillar, that supports clinical decisions. Other pillars include knowledge of established neurologic principles and informed clinical judgment" (Gronseth and French, 2008).

For the Student. You will not be able to become an expert statistician, researcher, and clinician in one easy lesson. The point is to remember this: the *sine qua non* of science is not a multimillion-dollar RCT, but an honest, objective, reproducible observation; a critical attitude; constant hypothesis testing; and a desire to seek and correct errors (McIntyre and Popper, 1983). A single piece of real data can confound the most elaborate theory or computer model. Make your own independent observations; write your findings down; check them against those of more skillful and experienced persons and against the results of radiographs and more sophisticated imaging and laboratory tests. Visit the laboratory and radiology department. Look at slides and images yourself; pathologists and radiologists are often eager to talk to students and clinicians. Do not scorn technicians; you can learn much from them. In the process of perfecting your skills with constant reality testing, you can hope to gain the balance of humility and self-confidence that characterizes the master physician.

The altar of truth is still the autopsy table. Never miss an opportunity to attend a postmortem examination. In a review of the work of Laennec in 1824, *The Lancet* stated as the standard for a physician's diagnosis: "recording at the bedside of the patient his opinions of the case, and in fatal instances of ascertaining by postmortem the real nature of the disease" (Warren and Warren, 1997). Despite modern advances in diagnostic technology, autopsy studies have shown high rates of missed diagnoses causing death (Leape, 1994).

Do not accept being placed in the position of medical students in the time before Vesalius (1514–1564), when dissections were done by an assistant a safe distance away from the professor. The professor intoned from a textbook without direct reference to the cadaver. Students were regularly told one thing, but they observed another (Wood, 1998).

Always be alert to the difference between evidence and GOBSAT (good old boys [and girls] sat at a table and decided) (Terrell, 2009).

Number Needed to Treat

The number needed to treat (NNT)—in order to obtain one additional favorable outcome—is another EBM concept that is more related to treatment decisions than to diagnosis, yet it can be important in prioritizing your work-up. The patient is harmed if a readily treatable condition is overlooked while searching for trendy risk factors, especially if he is then subjected to interventions with a very high NNT (and often, a low "number needed to harm").

The NNT is the inverse of the absolute risk reduction rate (ARR), which, for prophylactic interventions, is the control event rate (CER) minus the experimental event rate (EER):

$$\text{NNT} = \frac{1}{\text{ARR}}$$

For treatments, the ARR is the proportion improved in the treatment group minus the proportion improved in the control group.

One benefit of the NNT approach is to emphasize the importance of the absolute improvement rate, which might look much less favorable than the relative improvement rate. The latter is likely to be highlighted in presentations touting the benefit of an expensive drug or procedure.

Analogously, the number needed to harm would be the reciprocal of the difference between the proportion of the experimental group suffering a specified adverse outcome and the proportion of the control group having that outcome.

A Self-study question: The West of Scotland Coronary Prevention Study Group (WOSCOPS) RCT reported a 22% reduction in all-cause mortality rate in men aged 45 to 64 years with an initial mean cholesterol level of 272 mg/dL (7.0 mmol/L) who received 40 mg pravastatin daily, compared with the group receiving placebo, after 4.9 years of follow-up (Shepherd et al., 1995). The absolute percentage of men alive was 96.8% in the pravastatin group, and 95.9% in the placebo group. The absolute difference in survival was thus only 0.9%, a representation of the outcome that was not given in the abstract or the discussion (Kauffman, 2004). What was the NNT? (Appendix 1.5)

The Patient Is the Center of the Universe

The strict application of EBM implies a computer-like approach in which the doctor sees the patient as a statistic rather than an individual. This sort of medicine could be practiced by administrators. In the real world, however, clinical trials may tell which treatments are effective, but not necessarily which patients should receive them (Hampton, 2002).

Modern studies of the human genome and proteome have deepened our understanding of the importance and vast extent of biochemical individuality. Your patient could be in a subset of patients whose significant response to an intervention was diluted out in the large number of randomized subjects. It is recognized, for example, that two genes affect how patients process 25% of drugs now on the market (Marshall, 2003). Additionally, your patient is probably older than the experimental subjects, and probably suffers from multiple diseases requiring multiple treatments, which would have excluded him from the trial. Thus, the results of clinical trials may not apply to your higher-risk patient at all.

Study subjects may be quite atypical. A large number of prospective subjects are generally screened in order to select suitable subjects, and still more will probably have been eliminated, say, for failing to keep an appointment, during the run-in period.

Evidence-based medicine is distilled into practice guidelines, which have been filtered through the opinions of experts and journal editors. Opinion about the evidence, as opposed to the evidence itself, has a much greater importance than is usually acknowledged. In fact, "opinion-based medicine" might be a more appropriate term than "evidence-based medicine" (Hampton, 2002). Remember Frank Lloyd Wright's definition of expert: "a man who has stopped thinking—he knows!" (Oxman et al., 2004).

The important question is always "how is *this* patient doing?"—irrespective of the outcomes (which, more often than not, are surrogate endpoints) measured in an experimental group. The clinician who makes careful observations on one patient is also a scientist.

True science recognizes its limitations; advances in science depend on insights from practicing the art.

Appendix 1.1

Answer to the Question on the Stethoscope

The most important part of the stethoscope is the part that goes between the ears.

Appendix 1.2

Answer to the Question on Incidence and Prevalence

If the incidence is 10 cases per year and the disease is neither curable nor lethal, then by the end of the second year after the appearance of the disease, there should have been 10 new cases plus the 10 old cases, or 20 cases on the island. If the prevalence is 20 per 100,000, then the population of the island must (conveniently) have been about 100,000, assuming the birth rate and death rate to be equal and quite small and further assuming that no special perturbations have occurred.

Appendix 1.3

Analysis of Example on Testing Sequence

Test A will find all the cases of the disease, but it will also falsely diagnose four patients as having the disease for every patient who is correctly identified as healthy. (Look at the definition of specificity again, especially the denominator.) Thus, test A alone would have too much "noise" in its signal detection.

Test B will not erroneously label so many healthy persons as diseased. But it will find only half the number of persons who actually have the disease. In itself, it would not be a good screening test.

The correct answer is test A followed by test B. All the patients who are positive on test A, and only those persons, should subsequently be given test B. In this way, all diseased persons, and only such persons, will be identified.

The reverse sequence is not correct. First, one does not like to use the more expensive test first. What is the other reason?

Appendix 1.4

Answer to the Self-study Question on Prior and Posterior Probabilities

Using the nomogram, the finding of abnormal mental status increases the probability of pneumonia from 0.20 or 20% to about 0.36. Taking 0.36 as the pretest probability, the presence of abnormal breath sounds increases the posttest probability to 0.52.

Appendix 1.5

Answer to the Self-study question on NNT

The control (adverse) event rate CER (death in 4.9 years) was 4.1%. The EER was 3.2%. The ARR was 0.9%. The NNT was 1/0.009 or 111.

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CHAPTER

2

The Interview

It began to dawn on me that the healing art was not at all what people imagined it to be, that it was something very simple, too simple, in fact, for the ordinary mind to grasp. To put it in the simple way that it came to my mind I would say that it was like this: Everybody becomes a healer the moment he forgets about himself.

—Henry Miller,
The Rosy Crucifixion Book One: Sexus, Vol. 4, Chapter 14

Points to Remember:

- The patient is the most important person in the room.
- To learn things that other interviewers did not learn, you must win patients' confidence, make them feel that you are truly listening, and ask open-ended questions.
- The interview itself is part of the mental status evaluation. If the patient manifests signs of an organic brain syndrome, they must be specifically evaluated before the rest of the interview can continue.
- Remember to screen for addictions, especially alcoholism, even in patients who "don't look like a typical alcoholic."

First Principles of the Interview

1. The most important person in the room is the patient—any patient, any room.
2. Anything that the patient tells the interviewer must be held in strictest confidence. No medical person should ever say anything about any patient in a public place where laypersons, or any persons not entrusted with the care of a particular patient, are present (such as a hospital elevator).

This sign, once posted in the Medical Records Department of the Falk Outpatient Clinic at the University of Pittsburgh, should be reproduced in all medical institutions:

> What you see here,
> What you hear here,
> When you leave here,
> Let it stay here.

In the US at the present time, others such as third-party payers or officials exercising an "oversight" function may demand to access the information obtained in the course of caring for the patient. Related issues will be considered in Chapter 4. Material in this chapter assumes that the interviewer is acting as the patient's personal physician and not as a "provider" contracted with a third party or an agent of law enforcement.

Interviewing Style

Winning the Patient's Confidence

> For the fourth-year medical students at the Philadelphia General Hospital, my father devoted a number of lectures to the nonscientific aspects of medicine. He believed that confidence in a physician was of the utmost importance both for the well-being of the patient and for the doctor's success. Confidence, he explained, was first gained through the impression created by the doctor during the interview and physical examination.
>
> He thought a physician should appear to be pleased to see the patient; to think of nothing but the complaint; to be sympathetic and understanding; to be confident of effecting a cure and, if not, to take a cheerful note and inspire hope; to feel privileged to treat the patient; to be courteous and considerate; and be glad to take the time to hear the patient's problems.
>
> He made other suggestions about the ways the interview should be conducted. When extraneous matters came up, he said, the conversation should be gently and tactfully directed to the illness. He warned against talking about oneself, no matter how trivial or innocent it might seem (Schnabel, 1983).

Forget about yourself during the interview. Just permit yourself to get lost in the patient's story of his illness.

The Process of the Interview

The history is the story that the physician composes to help himself and others understand the patient's disease(s) as well as the patient's illness(es). The interview is the interpersonal process during which the raw material of such a narrative is evoked. The process is interactional, involving both verbal and nonverbal events. As the physician is evaluating the patient, the patient is evaluating the physician. Both patient and physician tell each other what they want to discuss and what they prefer not to discuss. Sometimes the physician tells the patient exactly what answer is desired, and sometimes the patient may also let the physician know what he is ready to hear.

All of this information is conveyed as the patient is describing numbers, colors, dates, and events and as the physician is recording these facts. Yet, both are recording, almost effortlessly, impressions of each other that will govern the relationship more or less in perpetuity.

The Czech poet Milan Kundera says that much of what occurs between a man and a woman devolves from the implied rules that they agreed to in the first few weeks of their relationship. Similarly, I would say that much of what occurs between a physician and a patient derives from the first 10 minutes of their first interview.

Most sophomore medical students are acutely aware that they are being scrutinized during the interview, just as they are scrutinizing the patient. In some cases, the attendant anxiety becomes disabling

to the student. In other cases, the intensity of this new situation prompts the student to say and to do that which he can immediately recognize as ineffective and revealing of his own neurosis. Yet in other cases, just the fear of looking foolish in itself produces ineffective behavior. All of these problems resolve with experience, although some students secretly doubt that they will ever be comfortable in the interviewing situation.

It is important for the student to remember his feelings of weakness and inadequacy so that he will always be able to recognize the same feelings in his patient and thus respond in an empathetic manner.

I have found from auditing sophomore medical students in their initial clinical encounters that they usually acquit themselves very well in spite of the feelings described above. A sense of mastery comes with practice. Feelings of the most severe apprehension generally subside when the student simply jumps into the situation and starts to work.

For the Senior Student. By now you have seen so many patients that you no longer have stage fright. The hospital has become a familiar workplace, and you have developed good techniques for getting things done. Perhaps now is a good time for you to reflect upon the way you felt the first few times that you introduced yourself to a patient. Your sense of novelty and strangeness has been replaced by confidence. But the hospital is still a strange and possibly frightening place to your patient. You need to respond appropriately to the patient's signs of anxiety, fear, or discomfort, rather than ignoring them because they are not germane to the piece of information you are trying to evoke at the moment. Although you should feel confident, you should not allow yourself to relax too much. Remember that the patient is observing your response to him and is deciding whether he will confide in you, what he will tell his family and visitors about the hospital or clinic, and to some extent whether he will agree to undergo the surgery or take the medication that you recommend.

The physician should be neatly dressed and groomed. If the interviewer is not wearing scrubs or other medical costume, dress and shoes should be appropriate for professional employment rather than a day at the beach. There are a few rare situations in which certain types of transference can be facilitated by wearing informal clothing. However, many older patients are offended by physicians who dress informally, as can be easily learned by asking them (provided that the interviewer really wants to find out the answer and is professionally attired at the time).

Remember that the patient evaluates the doctor as the doctor is evaluating the patient.

Before Beginning the Formal Interview

First introduce yourself to the patient and shake the patient's hand. The handshaking puts the patient at ease and is a sign of cordiality and respect. Diagnoses that can be made from handshaking are discussed in Chapter 24. (If the patient shows signs of rheumatoid arthritis or other painful conditions involving the hands, do not cause him pain by displaying your firm handshake!)

If others are present, ask the patient, "Who is with you?" In an office setting, it is especially important to make a note of the name and contact information of the patient's companion.

In the hospital, it is wise, after introducing yourself, to turn off all radios, television sets, tape recorders, and other distractions. If the patient's friends or relatives are present, they should be courteously asked to leave, with an estimate of how long you expect to be there. If close relatives are there, you should tell them, in the patient's presence, that you will not discuss anything substantive about the patient's care unless the patient is present and that they should ask the patient whatever questions they have. Close the door and pull the curtains when everyone has left.

Next, make sure that the patient is comfortable. You may need to plump up the pillows or to fetch the patient a glass of water. I have even been known to feed a patient soup or cereal, much to the amusement of house staff who believe that such tasks are suited only for nurses or other persons below the stature of a full professor. Such acts win the patient's confidence and convince him of your interest in him. The patient may subsequently tell you things that the other doctors did not learn.

Occasionally, the patient's family will not want to leave the room, and it is useful to find out why. On rare occasions, the interviewer may change his mind about allowing them to stay, at least for a portion of the interview, particularly if the patient is for some reason unable to tell his own story. With outpatients, the family may be most concerned about understanding the instructions for treatment, so that they may help a forgetful patient to cooperate. In that case, they will usually leave cheerfully if you promise to invite them back at the end, when you are explaining your instructions. (You should also write them down clearly and in large letters that a presbyopic patient can see.) The patient usually does not want his family to be present, even though you may not be able to determine that fact until the family has departed. *The most important person in the room is the patient.*

Just as relatives should be physically excluded from participation in the patient's personal interview, so should we also subtly diminish their roles as diagnosticians of the patient. Many patients are so dependent upon significant others that the physician's reasonable recommendations are ignored because of the counterrecommendations of a relative. The physician should not defer to a relative's opinion early in the interview. Although this attitude seems to be authoritarian in an egalitarian age, students who are to be taught to seize responsibility with one hand must also be given the opportunity to grasp authority with the other.

This advice is not meant to provoke confrontations with relatives. Mature physicians exert their authority subtly, kindly, gently, and unconsciously. If you smile at the relatives when you ask them to leave the room, they will usually not be offended.

Occasionally, a family member will insist on speaking to you—often by telephone—without the patient being present. The reason is frequently to confide information that he thinks the patient will not tell you, such as the amount of alcohol consumption. This information can be extremely helpful, and it might not be obtainable in any other way. (The same family member might deny the alcohol consumption if asked about it in the patient's presence.) However, it should not be accepted without skepticism; it may actually be a ploy to obtain information about the patient from you.

Circumstances in an outpatient practice are different, and physicians may prefer to handle family members and significant others differently (*vide infra*).

One way in which persons other than the patient can help in obtaining historic information in cases of poisoning is in performing

Figure 2-1 The "box test." A patient presented with an unusual picture of impaired consciousness, so a "box test" was requested. It was initially reported as "negative" for any drugs. In fact, the family member who had been sent home with the box was intoxicated and had returned with three onions! When the test was repeated the next day by a sober family member, the above medications were found in the apartment occupied solely by the patient. The major psychoactive material eventually identified in his blood was benzodiazepine for which six replicate prescriptions were found, shown here in the front row. Not surprisingly, a large number of the medications were indigestion remedies.

the *box test* (Fig. 2-1). Give the relative, or whoever found the patient, an empty box and ask him to collect all the empty and partially empty containers in the place where the patient was found, including those in the wastebaskets, under the bed, in the night table, and so forth.

Methods to Facilitate the Interview

Sit in a chair close to the head of the bed so that your head is down at the level of the patient's head, or as close to that level as you can comfortably get. It helps to raise the bed; this will also facilitate your movements during the subsequent physical exam and will reduce your own low back strain.

Lean toward the patient. Make eye contact. Ask an open-ended question and just maintain eye contact until something in the patient's narrative particularly draws your attention. Forget about anyone else at the bedside. There should be no one in the universe but you and the patient.

Allow no interruptions. Do not allow anyone to break into the interview. This is a rule that is very difficult to put into practice but that best teaches us its value when it is violated.

If at all possible, touch the patient during the interview. I find it useful to take the patient's pulse during the interview.

An Illustrative Story. There is an old story about the Arabic physician Ibn Sinna, who was consulted to see the king's only son. The son had fallen into a severe melancholia and was so withdrawn that he would not even speak to the physician. While the wise physician took the patient's pulse, he asked him, "Are you thinking about something happening here in the palace or something in the city?" The prince said nothing, but the physician noticed that the pulse rate increased just after the words "or in the city."

"Are you thinking about something on this side of the river or across the river?" asked the wise physician. Again, the young prince said nothing, but his pulse increased at the words "across the river." In this manner, the wise physician continued to examine the young man, learning that the young man had been smitten in love by a young woman he had seen in the town. The physician was even able to determine the exact location of the woman's house, although the young man had given not a single verbal answer.

Upon hearing the physician's report, the king had his guards send for the young woman. The king's son experienced a miraculous recovery as soon as she was brought into his bedroom. The wise physician was rewarded handsomely.

Question: What does this teach us about medical practice? (Write your answer before reading on.)

Answer: First, the story teaches us that all reactions are important, including nonverbal communication. Also, we learn that it is very difficult to maintain confidentiality, especially when powerful third-party payers are involved. It also teaches us that dealing with third-party payers is sometimes financially rewarding to the physician. And, of course, it teaches us to stay in tune with the patient throughout the interview—the answer that you should have written down.

Ask an Open-ended Question

The best way to begin the interview is with an open-ended question. Skill at asking such questions probably determines one's success as a physician more than any other factor.

Two requisites must be satisfied, in the given order. First, *the patient must know who you are*. The introduction may be performed by one of the patient's physicians:

1. "Mr. Smith, these are the two medical students I told you about. They are going to spend about 2 hours with you this afternoon, if that's still all right with you." Or:
2. "Mr. Smith, this is Dr Blue. He is our attending physician. I mentioned to you earlier that we would be bringing him around to meet you." Or one may introduce oneself:
3. "Mr. Smith, I'm medical student Jones, and this is my partner, Mr. Black." Or:
4. "Mr. Smith, I'm Dr White. I'm a consultant in endocrinology. Your doctor, Dr Green, asked me to come by and see you about your diabetes, your sugar problem."

After the introduction, pause to give the patient a chance to ask a question, if he has one ready. If not, as is usually the case, proceed with the interview.

The second requirement for success is that the *patient must know what you are doing*. With a brand new patient, I like to explain: "I'm going to take the story of your life. I'm going to ask you an awful lot of questions. Then from your answers, I'm going to have some general idea of what the problem may be. Then, when I've finished asking you most of the questions, I'm going to examine you. When I finish that examination of your body, I'll have a much better idea of what the problem may be. At that time, I'll also have an idea of what laboratory tests and/or X-rays we'll need to solve your problem. Do you have any questions now about how I'm going to proceed?"

Continuing the four dialogues begun above, this second stage might be accomplished by the following statements:

1. "We're Jones and Black. We're sophomore medical students, and we won't be participating in your medical care after today. We're only student doctors, and we're your doctors just for this afternoon. Before we get started, is there anything you need to make you comfortable?"

2. "Hello, Mr. Smith. We've been discussing you in the conference this morning, and I felt it very important that I actually meet you and go over the details of your story. I also want to examine your heart to double-check a few things."
3. "We are going to talk with you and go over the details of your medical history, and then we are going to examine you just as your other doctors did."
4. "Dr Green is a bit puzzled as to why your sugar has been swinging up and down so much, and I am going to try to help him and you, if I can."

Each of these statements is followed by a pause and a check to see that the patient understands what has been said.

Finally, the stage is set for the first of many open-ended questions. To continue the four dialogues, they might be

1. *"Can you tell us what brought you to the hospital?"*

   "Yes. It was my nephew's Ford." (This patient has examined many sophomore students.)
   "No. I mean, what was bothering you? What were your symptoms?" (A double question. See later in this chapter.)
   "What was bothering me? My mother-in-law."
   "No, we meant why did you come to the hospital?"
   "Well, I'm a Korean War veteran. And this is the Veterans Hospital, isn't it?"
   "No, we meant why come to the hospital at all? In what way did you feel sick?" (Another double question.)
   "I always feel this way when I'm sick."
   "Well, when did you last feel well?" (An excellent open-ended question.)

2. *"Could you begin by telling me when was the very first time you noticed anything that might be related to your heart trouble in any way?"*
3. *"When was the last time you felt in perfect health?"*
4. *"When was the very first time you were aware that there was anything different about your sugar?"*

Notice that the second and fourth questions would not be open-ended for an initial evaluation but in reality are open-ended for an interviewer who has already heard a complete history secondhand. To see what I mean, consider the following counterexamples of unhelpful "closed" questions:

1. "When did a doctor first tell you what was wrong?"
2. "Did you have orthopnea before last January?"
3. "Have you ever been in the hospital before for the same problem you are having now?"
4. "When did Dr Green first tell you your sugar was too high?"

For the Neophyte. Much of the material in this chapter may seem quite formal and rigid to the thoughtful reader. However, those students who initially learn to be very obsessive, rigid, compulsive, and thorough will develop excellent interviewing skills; later, they can discard any excrescences. On the other hand, individuals who initially use a sloppy interviewing technique tend later to have a smaller repertoire of adjustments for the individuality of patients.

To illustrate the value of the rules, I like to tell the following story to my students.

There was an extremely busy physician who had a large and ever-increasing general practice, which included many families. One night he was running late as usual. After his office nurse had helped him an hour past her quitting time, he asked whether there was anyone left in the waiting room.

"Just Mrs. Smith," she said.

"Well, you can go home," said the doctor. "I can gown her and put her on the examining table as well as you, and you have worked long enough."

The doctor finished what he was doing, put away the previous patient's chart, and went to the waiting room, where he saw a man and a woman sitting together.

"Come in," he said, holding the door open as they walked in and sat in the two chairs opposite the doctor's desk.

He seated himself and asked, "What seems to be the problem?"

"Well, doctor," said the man, "to tell you the truth it's a little bit embarrassing." The man then launched into a description of a skin lesion that seemed related to some sexual difficulties. The patient explained in great detail the highly unusual things he had done in the course of acquiring his lesion.

"Well," said the doctor, "just go into the examining room, take off all your clothes, and lie down on the table. I will come in and examine you."

When the man had left the consulting room, the physician turned toward Mrs Smith, whom he had never imagined would engage in such unusual practices. "Is all this true?"

"I don't know, doctor," said the woman. "I've never seen that man before."

This apocryphal story demonstrates that if you violate too many of the rules given in this book, you will sooner or later get into trouble. It also demonstrates the enormous authority afforded a physician in his area of expertise, as well as the physician's ability to sanction social behavior.

The patient-centered principles underlying this style of interviewing will serve one well in other circumstances, including seemingly unrelated cases. For example, consider the following story in which the student had to decide what to do when the patient's biopsy was positive for disseminated carcinoma.

Self-study

A woman was admitted to the hospital for a diagnostic evaluation. Both she and her husband were aware that the doctors might find a terminal form of cancer. The husband, a patriarchal Sicilian, took the doctors aside and said that if the biopsy was positive, the patient was to learn of the diagnosis only from him, the husband. The woman separately told the doctors that she wanted them to tell her the biopsy result if it was positive for malignancy.

The biopsy was positive, and the medical student told the patient the results, as she had requested. When the husband learned that the information had not been "filtered" through him, he became furious with the medical student. The student was castigated by the house officer for not considering the cultural traditions of the patient and her husband.

What would you have done?

Discussion

While the house officer is to be commended for his consideration of cultural factors in the management of patients (if not for his delegation of such a responsibility to a third-year medical student),

we must return to the patient's wishes. Obviously, in this situation, the patient herself was not willing to maintain total dependency in her relationship with her husband; thus, she may be considered to have abrogated any obligation of the physician to adhere to any (putative) culturally determined sequencing of the presentation of information. In other words, she was better aware of her own culture than anyone else and yet had clearly stated whom she wished to be informed first of the diagnosis—herself.

Interviewing versus Interrogation

Thirteen Rue Madeleine, a World War II motion picture, formerly popular on late-night television, is named for the address of the Gestapo headquarters in Paris. In the final scene, an American spy (played by James Cagney) is interrogated by the head of the Gestapo (played by Richard Conte). Cagney has called in a bomber strike on 13 Rue Madeleine that will destroy the Gestapo operations in occupied France but will just as surely destroy the patriotic Cagney. Conte is torturing Cagney to find out what radio message he had sent back to the Allied Forces.

I use this scene in teaching because there is a certain style and rhythm to that interview as it becomes an interrogation. Conte's voice and attitude are those of a superior figure addressing one who is in a dependent position. Furthermore, the superior figure is obviously indifferent to Cagney's suffering, and he is hostile and wantonly cruel.

Except in the movies, I have heard that interviewing style only in hospitals when I have been thrust into the role of unintended eavesdropper on medical house staff and, sad to say, some medical students. This style is not suitable for physicians. It is certainly not the way to elicit sensitive information. Students should choose to identify with a more desirable mode of behavior and to overcome any latent tendency to become brusque with patients.

Avoid "Leading the Witness"

Interviewing is a two-way street. The patient responds to the doctor's wishes, and sometimes doctors with a poor interviewing style insist on being told what they want to hear, as the following story illustrates.

A patient was transferred to the medical service of a tertiary care hospital, instead of the neurologic service, despite the fact that he was suffering from a stroke. At the referring hospital, no one had been interested in his paralysis, but they had been interested in chest pain. In fact, the patient had experienced no chest pain, but after vigorous and repetitive questioning about this symptom, "They talked me into having chest pain." Because the doctors at the tertiary hospital were also concerned about the paralysis, it again became permissible for him not to "have" chest pain. Remember that you are interviewing the *patient*, not the medical record or the patient's previous physicians.

Choice of Language

Always use words that the patient understands. Never use technical or medical terms in the interview. This seems like good common sense, but you need to be aware that because you are just beginning your own mastery of these words they will slip into the clinical interview, and the patient may not tell you that he does not understand. If you are sure that you would never make such a mistake, audit tape recordings of your own interviews. Sooner or later, you too will use a medical term the patient does not understand. As in so much of medicine, awareness of the problem is an obligatory first step toward its solution.

On the other hand, try not to go overboard in the opposite direction. When interviewing a patient who belongs to a subculture with its own jargon (such as a drug abuser or a prisoner), one should not enter into the patient's argot (see later in this chapter). First of all, language serves important ego-defensive functions. Second, the physician should never interview in an unnatural style any more than he should attempt to perform surgery from an unnatural posture.

Of course, the problem of misunderstanding the terminology can go in the other direction as well. Certain obscure slang terms and abstruse euphemisms are used by patients, especially when the disease may have social significance. For example, "bad blood" was a term used to denote syphilis and, later, by augmentation, any venereal disease. (At other times, "a hair cut" had the same meaning.) But "bad blood" had to be distinguished from "low blood," which could be either anemia or psychasthenia in a patient with a normal blood pressure. Worse, in different parts of the country, the same phenomenon may have different names. Lymph nodes have been variously referred to as "knots," "lungs," "kernels," and "risings" (the last may also be an abscess). Even within one locality, the names may change from time to time. For instance, when I started work at the hospital for drug addicts then in Lexington, Kentucky, I found a glossary of terms that someone had compiled a few years earlier, apparently to distribute to new medical officers. However, half of the terms were arcane or forgotten and many had been replaced by new ones.

"Can You Tell Me What Bothers You the Most?"

Some patients will come in with lists of problems, written or otherwise. They may jump from problem to disease to event to syndrome to hospitalization to symptom, without ever finishing the description of any of them. For the neophyte intent on eliciting all the dimensions (see Chapter 3), getting the correct chronology, or simply developing a clear understanding of what the patient is trying to say, this can be very annoying. The title of this section is a useful response. This question helps the patient focus on whatever he feels is really important. In some patients, it also makes it clear that a particular problem is not needed to serve as the "ticket for admission"; you are interested in whatever is making the patient ill with life, even if he is not nominally diseased. Why do patients need a "ticket of admission"? Many patients would like to talk to a sympathetic doctor about personal problems not parochially thought of as "medical problems." In fact, the urgency to talk about such problems and to take up the physician's time has led to the creation, in some institutions, of whole departments (psychiatry, psychology, social work, behavioral medicine, ombudsmen) devoted to listening to patients talk about what really bothers them, while the physician obliviously orders more nondiagnostic tests. The truly thoughtful physician will want to know about these concerns. However, some patients can only come to see the physician if they have something that will get the receptionist to give them an appointment or, in larger institutions, that will satisfy some bureaucratic, algorithmic guideline. Once the patients get into your office or the hospital,

there will be a natural tendency to talk about the true subject of their discomfort—as soon as they believe they can safely bring it up. The question that is the title of this section can help the patient bring up the problem. Some professors may object to this use of their time, but if they will recall the number of patients who have tried to rekindle a conversation while being shoved out of the office, they may reconsider and use the question to initiate the discussion at the beginning of the hour or quarter hour. (See the section entitled "Organ Recital," in this chapter.) Because we insist, properly, on the patient having a chief complaint, we should not be surprised that the patient wants to satisfy us.

For a number of years, I abandoned the teaching of this question because of its misuse. Instead of using it to encourage the patient to talk, some were using it defensively to get the patient to stop talking about problems that did not interest the doctors. Furthermore, if challenged on having missed an important diagnosis, the resident might respond, "Well, I asked her what bothered her the most, and that's what she told me."

An important principle in medicine is that even the best teachings can be subverted. The corollary is that the thoughtful physician will choose his company wisely, associating with those who are wiser than himself, if possible. As the *Talmud* instructs, "If you wish to be a scholar, you must seek out the company of other scholars."

"Tell Me More…"

In the initial open-ended portion of the interview, the patient will usually stop talking before he has told you all the details of some important event (such as the dimensions discussed in Chapter 3). He may previously have been interrogated, not interviewed; he may previously have had so many bad doctors that he is puzzled that anyone should want to spend so much time listening to him; he may simply be taciturn; or he may simply not be aware of the importance of certain details. You want to keep the patient talking, but how do you do it?

Just say to the patient, "Tell me more." A few of these phrases sprinkled into the interview act like yeast in bread dough. Some patients will ask, "About what?" The answer is, "About what you were just telling me." Others will ask, "What do you want to know about it?" Your answer is, "How you felt about it," if you cannot think of a specific aspect in which you are interested.

Once the patient senses that you are truly interested in him, he will respond positively to the request, "Tell me more."

Of course, later on in the more staccato portion of the interview, there will be events or symptoms about which you may wish to have more detail. Here too, it is a good idea to say, "Tell me more." If you have already used the phrase effectively in the initial part of the interview, it will begin to function like a conditioned reflex.

The student must master the open-ended interview before proceeding to the decorticated checklists being promulgated by some supposed medical educators.

Assessing and Improving Your Interviewing Skills

If medicine is truly a science humanely practiced (Eichna, 1980), we must note that science inevitably depends upon measurement. In order to make measurements, one must have a method of recording events and data. One should not expect an electrocardiographer to teach a neophyte if the latter could only describe an arrhythmia as a "little wiggle, then a pause followed by a big wiggle." But if the neophyte brought an electrocardiographic tracing, the electrocardiographer could measure, diagnose, and teach; and the neophyte could learn in a meaningful way. The same is true for interviewing; one learns best from a recording that can be played back and examined.

Videotaping is discussed later. For the time being, let us consider audiotape recorders because these are cheap and ubiquitous.

Making a Recording

Immediately after you have introduced yourself (if not before), turn on your recorder and place it where it will not interfere with eye contact between you and the patient. Experiment ahead of time to be sure that the device has an adequate microphone. Older devices may need an external microphone. Remember, the patient is the most important person in the room. Most of the interview content comes from the patient, not the interviewer.

Tell the patient, "I'm going to record what you tell me so that I am certain to get everything correct," or words to that effect. If you are recording only for technique (form) and not for content (*vide infra*), the statement is not strictly true. Because we do nothing with the patient sub rosa, you might simply say. "I want to record what you say" or "I want to record our conversation," or "I want to have a record of what we say to each other so that I can review it later."

No matter what explanation you give for recording the interview, be sure to assure the patient of confidentiality. You might say, "I am going to review this alone, using an earpiece, so no one else will hear," or "I am going to go over our interview with a more senior doctor who is teaching me about talking with patients," or "No one will hear the tape recording but me," or whatever is true. Be sure to add that the tape will be permanently erased and that no one who knows the patient will ever hear it.

Needless to say, your assurance of confidentiality must be honored. Listen to the tape privately, or only with concerned parties, as you promised. If you share lodging with a nonprofessional, you should use an earpiece. And, of course, if you promise the patient that you will erase the tape, or delete the digital file, you must do so. I have never had a patient decline to be recorded. Those situations in which students claim that the patient refused to give permission to record the interview were themselves always unrecorded. If you are truly concerned about legal issues, you may say at the end of your introductory comments, "Do you mind if I record us?" or "May I have your permission to make a recording?" If you are afraid of listening to your own interview, you will ask the question in a manner that guarantees that many patients will oblige you by refusing to give permission.

During many years of interviewing medical patients in front of small groups, I have found that, recorded or not, most patients have little hesitancy about speaking openly, with absolutely no embarrassment, if they sense that the listeners are really interested in them. The patients realize that the situation is a well-defined professional one, not a social one. If you carry yourself as a professional and treat the patient in a professional manner, the patient will treat you as a professional and will give you an amazingly sensitive and accurate account of his experiences.

Reviewing the Recording

After you have made the recording, listen to it in the quiet of your own room. You can review the content of the history of the present illness; although if that were the main purpose, I would have placed this section in the chapter on history, not in the one on interviewing. The most important purpose of the recording is to improve your skills in interacting with the patient.

Studies of medical students interviewing patients have found that there are four different objectively measurable phenomena that are highly correlated with experienced clinicians' global ratings of the quality of the interviews: interruptions, percentage of time that the interviewer speaks, pregnant pauses, and double questions.

These four criteria permit you to score your own tape recordings. However, even within one interview, different portions of the interview have somewhat different structures. Thus, to be perfectly scientific, one should randomly select samples from different portions of the entire interview. With each criterion to be discussed, we will also discuss its major variations among different portions of the interview.

Criterion 1: Interruptions

On the average, there should be no more than 1.5 interruptions per minute of interview. This is especially critical in the portion of the interview that comes at the beginning and produces content usually found in the history of present illness portion of the case record.

An interruption should be scored whenever the interviewer interrupts the patient while the patient is speaking.

Example of an Interruption

Patient: "… You know doctor, I have always wondered if that shortness of breath had anything to do with the time …"

Interviewer: "When did you say your ankles first swelled up?"

A distinction can be made between flagrant interruptions and the skillful interviewer's shaping comments. A shaping comment gets the patient back to where the interviewer wishes to be by recounting something that the patient has already said.

Example of a Shaping Comment

Patient: "… and the following spring, regular as clockwork, I got another one of the asthmatic attacks. It was the same thing as last time, starting with coughing and spitting and getting me up at night just like the first two … there was that coughing and spitting. It seemed like every night I would get up just like the past year. Regular as clockwork at 1:00 a.m. there was that coughing and spitting …"

Interviewer: "Was that spring the first time you noticed the blood?"

What If the Doctor Did Not Interrupt?

The average patient visiting a physician in the US gets only 22 seconds for his initial statement before the doctor interrupts. Physicians are apparently afraid that they will fall behind in the schedule if they permit patients to talk as long as they would like. A Swiss study conducted in a tertiary referral center investigated how long patients would talk if allowed to do so. Physicians were trained in the basic elements of active listening and ways to encourage communication (nodding, echoing, using facilitators such as "hmmm, hmmm") and advised to interrupt if a patient talked for longer than 5 minutes.

The mean spontaneous talking time was 92 seconds (SD 105 seconds, median 59 seconds). About 78% of the patients finished their opening statement in 2 minutes. Only 7 of 331 patients talked longer than 5 minutes, but in all cases, the physicians felt that the patients were giving important information and should not be interrupted (Langewitz et al., 2002).

Criterion 2: Percentage of Time the Interviewer Speaks

On the average, the interviewer should speak no more than 50% of the time and no less than 10% of the time. With a young, healthy person who has a completely negative review of systems, it is not uncommon for the interviewer to be speaking from 45% to 50% of the time during that portion of the interview. However, in the history of the present illness portion, the interviewer should be speaking closer to 10% of the time.

The reason for the 10% lower limit is that in certain interviews the interviewer loses control to a loquacious patient. It is true that an excellent interviewer with good nonverbal cuing can let the patient speak more than 90% of the time during fruitful portions of the interview that will produce material for the history of the present illness. But on the average, over the course of the entire interview, no skillful medical interviewer will speak less than 10% of the time.

Criterion 3: Pregnant Pauses

This is the hardest portion of the interview to learn. One must be aware of the technique and use it deliberately. A really good interviewer should be able to produce a pregnant pause, 4 or 5 seconds in length, several times during the interview.

A pregnant pause is defined as the silent interval between the apparent end of a patient's response to the question and a thoughtful continuation, not interrupted by any comment or the next question from the interviewer. The pregnant pause is terminated by the patient himself resuming a more detailed description of whatever he was discussing, usually with an enriched context.

A pause for 4 or 5 seconds may not seem like very long, but it is long enough to make the naive interviewer very uncomfortable. It is suggested that the novice develop a nonverbal cue such as smiling, leaning forward, motioning with the hand, or taking off his glasses and motioning with them in a "continue, please" manner. Extremely skilled interviewers can leave up to 20-second pauses when asking about prior imprisonment, sexual matters, or other taboos for that particular patient. Pregnant pauses are usually found in the portions of the interview having to do with such potentially sensitive subject matter.

Criterion 4: Double Questions

Always ask one question at a time. Although this dictum seems rather obvious, you will almost inevitably violate it. If you carefully audit the recordings of your interviews, you will find instances in which you have asked a second question without waiting for a response to the first.

Examples

Interviewer: "During any of this time did you cough up any blood—did you say you once worked in shipbuilding? Were you ever exposed to asbestos?" Or:

Interviewer: "Have you noticed any change in the frequency of your bowel movements since the operation? What about the color? Did it change?"

A study of paired tape recordings and case records reveals that the answer to the first question is always omitted from the case record, and for a very good reason. The patient always answers the second question, never the first. Worse, the interviewer never goes back and repeats the first unanswered question.

If one interviews the interviewer and asks about the omitted information, the inevitable response is frustration, as he remembers asking the question but is not able to remember the patient's answer because, of course, it was never given.

Other Criteria

Any good physician who has been in practice for a long time has a number of interview criteria of which he is not consciously aware. You might wish to play back an interview for a private physician who is willing to serve as a tutor. Physicians of experience can immediately point out technical errors even though they may never have specifically thought about the right and wrong ways to conduct an interview.

Nonverbal Communication

There are three aspects of nonverbal communication to be considered: tone of voice, body position, and facial expressions. The latter two are best taught by means of a videotape.

Tone of Voice

While the importance of this factor is rather obvious, persons who do not use tape recorders often do not realize that their tone of voice is sometimes not what they believe it to be. Many students, upon hearing themselves for the first time interviewing a patient, remember the patient's voice but wonder who the person asking the questions is! Again, the simple use of the recorder will solve this problem, given a student of intelligence and sensitivity.

Body Position

The interviewer's body position with respect to the patient determines much about the content of the interview. Physicians who always stand above a supine patient are perhaps unconsciously reinforcing the patient's dependent position and the authoritarian position of the physician. While some physicians know how to utilize this discrepancy to the ultimate advantage of the patient, others may abuse it. In later years, I have always attempted to spend at least some time sitting by the bedside at eye level with the patient. My having the chair at the bedside, while the rest of the team is standing, is often misinterpreted by the junior members of the team. But it makes better eye contact possible, and it shows the patient that I plan to sit and listen to him. Patients also perceive that physicians who sit at the bedside are spending more time with them than physicians who stand, whether or not that is true by objective measurements.

The physician's body position can be consciously used to control certain aspects of the interview. Conversely, body movements of which you may be unaware can be counterproductive. For example, breaking eye contact, turning your body away from the patient, looking at your wristwatch, or staring into the corner will decrease communication, both quantitatively and qualitatively. Conversely, if you wish to get a reticent patient to talk, kinesic encouragements could include the following: holding your body so that your line of vision is in line with that of the patient's, leaning forward slightly but comfortably, and using skillfully placed signs or motions of encouragement when the patient stops talking. The last include, but are not limited to, a "come here" motion with the hands; taking off one's glasses and using them in a "hooking the patient in like a fish" movement, with or without accompanying head movement; nonverbally saying, "Yes, go ahead" by smiling; head nodding, which also indicates approval; and a rotary mixing-in motion of pen or pencil with the fast component moving from the patient to the interviewer.

Suggested Teaching Exercise

Videotape an interview but with the camera pointing at the interviewer rather than the patient. Play it back first with sound but no picture. Then play back the picture with no sound. Finally, play the sound and picture together.

When listening to sound only, note what unexplained pauses occur. When looking at the picture only, analyze the body signals. Do you see any negative ones? When listening to the sound with the picture, do you see any correlations or contradictions between the patient's verbal behaviors and the interviewer's physical behavior? What other obvious mismatches could you detect with sound and picture that were not apparent viewing just one?

Facial Expressions

Frowning at the patient will decrease communication. Smiling at the patient will encourage the patient to talk. Salesmen of all types use this technique.

Autognosis

Autognosis is a combination word from auto (meaning *self*) and diagnosis. It refers to diagnosis through awareness of the feelings that the patient engenders in oneself. While it may be formally taught as part of the specialty known as psychiatry, its application need not be limited to psychiatrists, any more than the interpretation of chest films need be left to radiologists. Autognosis is useful in certain specific disorders (see Chapter 26). Some depressed patients tend to make the physician feel depressed by the end of the encounter; similarly, some manic patients tend to be amusing, making the physician smile or laugh. Patients with less well defined psychiatric disorders (or no psychiatric disorder at all) may evoke in the physician feelings similar to those they evoke in their employers, employees, associates, parents, children, siblings, or spouses.

Being aware of your emotional reaction to the patient also helps you to guard against what Groopman calls "affective errors"—concentrating more on data supporting a desired outcome (Groopman, 2007), such as a benign diagnosis in a patient one especially cares for, or quick dismissal of a troublesome patient.

Again, I emphasize that interviewing is an interactive process. The physician can learn to take advantage of a spontaneous, free, and noninvasive diagnostic aid: His own emotional response.

Last Question in the Interview

As you move from the open-ended questions at the beginning of the interview to the more specific kinds of questions that are covered in the next chapter, you will be formulating differential diagnoses in your head. Then you will move on to the physical examination. When you finish the physical examination, you will be considering which laboratory tests you wish to order. I would suggest interrupting the sequence by inserting, just before the physical examination, the following question: "Is there anything else you want to tell me?"

Some British-trained physicians say, "What do you think is wrong with you, Mr. Smith?" in order to get the patient to think of more diagnostically related material and to learn the patient's as yet unspoken fears, but this is not really the same question. The "anything else" question is not limited to diagnosis but includes prognosis, therapeutics, fears, worries, terrors, and even trivia (from the physician's standpoint) such as information concerning rest rooms, visiting hours, or parking near the office. The question does not guarantee the quality of the diagnostic content of the response, but it does facilitate the patient–physician relationship.

This closes the interview in an open-ended style. It also prepares the patient to begin the next interview in an open-ended fashion.

One difference between psychoanalysis and the interview is that the interview never terminates and lasts for the life of the patient–physician relationship. (See Freud's essay on the subject of psychoanalysis, terminable or interminable [Freud, 1937].)

The Psychodynamic Termination of the Physical Examination

This section is not out of sequence. There is a portion of the interview, or a potential portion of the interview, that actually occurs at the very end of the patient–physician contact. Of course, everyone realizes that we continue to talk to the patient (to perform an interview) even as we perform the physical examination. However, most people do not understand that the termination of the physical examination is also the termination of the interview and is psychologically very important.

Patients often say very important things to you as you are leaving the room. As an aid, I suggest that you leave your tape recorder running as you exit, since you may be inattentive to the patient's comments after you have said good-bye. You may not want to leave your tape recorder running all through the physical examination for logistic reasons. In that case, turn it back on just before you leave, and study the last part of the recording carefully.

From a psychodynamic standpoint, the most important part of the interview occurs as the physician and patient part company. The phenomenon is much easier to observe in an office setting.

There are several reasons why patients give psychologically important material as they are leaving. You are distracted, unguarded, and not really concentrating on the patient. You may have put away his chart and pulled out the chart of the next patient, to whom you are, appropriately, switching your attention. The patient, for his part, is in a relatively safe position. He is no longer recumbent, dependent, prone, or under your gaze. He can throw out a comment and observe your response. If he does not like your look, gesture, or tone of voice, he already has his hand on the doorknob and will soon be safely outside. His remark may be a new symptom (see "Organ Recital," this chapter).

What can be done about this situation? First, use a tape recorder in the outpatient department to convince yourself that the above is true. Second, awareness in itself is helpful, as in so much of medicine. One way to handle the situation is to look up at the patient and say, "That would be a good place for us to start next time," assuming of course that there is to be a next time and that you will start there.

Understanding the nuances of the patient's parting remarks requires some training in psychodynamics. The lack of availability of such training in most medical residencies is a serious deficiency.

For the Attending (a Rounding Ploy). As the rounding group leaves the bedside, turn your back to the patient and begin washing your hands. (Those who believe in the germ theory think that this is a good idea in any case.) This will permit you to eavesdrop upon the rest of the group as they leave the patient's bedside. Listen to the patient's last words to the group. After you have left the patient's room, ask whether anyone can remember the last thing the patient said. If no one can, remind them of what it was, and possibly also comment on why some people cannot remember. It will probably not be difficult to interpret the patient's comments, if they did have some especially significant meaning. Experienced attending physicians know far more about human behavior and patient–doctor interactions than they realize. These insights should be shared with younger colleagues, because one of the purposes of civilization is to spare the young of the species from having to learn everything the hard way.

Notes on Office-based Practice

Physicians with a patient-centered office-based practice disagree with some of the advice given above, particularly with respect to accommodation of the patient's spouse, relatives, or significant other. Some physicians prefer to have the companion present for at least part of the interview, if the patient wishes, as well as the sessions explaining findings and treatment options. The companion's participation in the discussion is permitted and encouraged. The arrangement of the consulting room, with provision for comfortable accommodation of a family member or friend, reflects this preference. Observing the interaction with the companion is a critical part of the assessment. Moreover, the cooperation of people the patient trusts may be essential to the success of the therapy. It is also important for the patient to have an opportunity to share confidences with the physician alone, say when the companion is asked to wait in the reception area during the physical examination, treatment session, or at another time.

It is helpful to start with the question "Who is with you?" even if the patient comes into the consulting room alone. Taking obvious note of the person's telephone number conveys to the patient that the chosen companion is a partner in the healing enterprise.

The questions "Who is at home with you?" and "Who is the person closest to you?" can uncover much about the patient's social situation without being intrusive or appearing voyeuristic.

A comprehensive evaluation as described in these chapters is not necessarily appropriate for every patient who consults a physician, particularly a specialist. Private patients may not wish to spend the amount of money required for such an evaluation. Or they are simply too reticent to share sensitive details. Some private physicians ask "What would you like me to help you with?" early in the interview. Part of a physician's skill is in knowing what information he needs to accomplish the mutual objectives. The physician who has an ongoing relationship with a patient also knows that not everything can be done in a single visit. This follows from the belief that the "one diagnosis, one treatment" paradigm is flawed. Patients often have a number of interacting problems that can be sorted out only in a process of trial and error or successive approximations. The physician cannot just write a diagnosis on a "problem list" (see Chapter 4), prescribe a pill or combination of pills, and schedule subsequent visits simply for refills or adjustments.

I learned a unique use of the tape recorder from a physician in private practice. After the initial interview and examination, he explains his synthesis of findings and recommendations to the patient and companion. This session is recorded on audiotape, after the procedure is explained, and the only cassette is given to the patient at its conclusion. The patient can then review the discussion as often as desired, and allow others of his choosing to listen also. This procedure enhances informed consent, allows patients to review instructions they may not remember well, and demonstrates the physician's trust and confidence in himself and the patient. This probably helps to protect against lawsuits as well as to improve patient understanding and concordance.

Interviewing Patients Who Are Forgetful or Confused

Recognizing the Presence of an Organic Brain Syndrome

The most common cause of forgetfulness is cerebral (or cognitive) insufficiency, which has been called an *organic mental disorder* or *organic brain syndrome*. These are unfortunate terms (see the definition of organic in Chapter 1). The concepts are still useful, however, especially in the emergency department, or before the physician is able to characterize the condition more precisely. In my view, there is no completely satisfactory substitute that encompasses degenerative conditions, metabolic encephalopathies, and other conditions with a known structural or physiologic substrate that may call for medical investigation and intervention, as opposed to psychiatric consultation, behavioral intervention, or psychotherapeutic drugs.

A Historical Note on Terminology

The term *organic mental disorders/organic brain syndromes* was included in the diagnostic and statistical manual of mental disorders III (DSM-III) of the American Psychiatric Association to encompass conditions falling in the no-man's-land between psychiatry and neurology. The schism that occurred in the mid-20th century between psychiatry and neurology isolated and ignored an entire group of patients with behavioral changes related to neurophysiologic changes rather than psychic background and social pressures (Strub and Black, 1981).

The term was deleted from the DSM-IV because it implied that serious psychiatric disorders such as schizophrenia did not have a biologic basis. The conditions formerly listed in that category were regrouped under a hodgepodge of other classifications, including cognitive disorders such as Alzheimer disease and "Mental Disorders due to a General Medical Condition."

Manifestations of an Organic Brain Syndrome

An organic brain syndrome manifests itself during the interview by the patient's contradicting himself, having difficulty recalling details, or in some cases evading the questions. The patient may seem to do well on open-ended questions but develops difficulty when asked more specific ones.

The word *history* comes from the Greek *historia*, meaning inquiry, which was the title of the earliest extant historical work, written by Herodotus. The practical point is that the *historian* does not live the history, but records it (as Herodotus did; see quotations in Chapters 10 and 20). When we read in a case record of a *poor historian*, this refers to the same person as would the term *poor auscultator* or *poor ophthalmoscopist*. If *poor historian* refers to the patient, it would mean that he is an impecunious student of the past, a piece of information that belongs in the social history, not following the statement of reliability (see Chapter 4). In other words, *the physician is the historian*.

What the historian might have meant to say by his phrase *poor historian* was that the patient has difficulty remembering. Such a memory problem is a biologic event, like fever or tachycardia, and is equally deserving of an explanation. To note the patient's difficulty in recounting his story the same way on any two sequential attempts, or his inability to remember material of the type that most patients would be expected (by us) to remember, should be the beginning of an evaluation, not its termination. These observations should suggest to the physician that the patient may be suffering from an organic brain syndrome. Suspicion should also be aroused if the patient's performance is variable or fluctuating; or if he is disorganized; shows lapses in concentration; or confabulates, often to the annoyance of the physician. The physician is obligated to determine whether the forgetfulness is in fact due to such a syndrome, then to find out the etiology of the syndrome so that any potentially reversible problems can be treated.

Accordingly, when one is interviewing such a patient and one even barely suspects the presence of an organic brain syndrome, one must stop the interview per se and evaluate this problem.

It should be noted that the brief cognitive portion of the mental status examination about to be described is actually part of the neurological examination (see Chapter 26). However, the neurologic examination is not described until the end of this book (as is true of most other textbooks and courses). Because between 10% and 40% of the patients on a medical or surgical service will have an organic brain syndrome at some time during their stay and because such patients will give a very confusing account, it is important that the cognitive portion of the mental status be assessed as soon as possible, if for no other reason than to avoid wasting the physician's time gathering confabulated data. Thus, this is one portion of the

physical examination that must, in many cases, be performed near the beginning of the interview.

Acute Organic Brain Syndrome (Delirium)

In a classic paper, the name *cerebral insufficiency* is suggested as a better synonym for delirium (Engel and Romano, 1959). Nevertheless, the term *delirium* is still incorrectly used by some to refer to an agitated patient, a patient who is hallucinating, or even a stuporous or comatose patient. To avoid any misunderstanding, it is probably best to avoid using the term *delirium*, except among the cognoscenti. "Acute confusional state" may be preferable these days.

The terms *toxic psychosis* and *metabolic encephalopathy* actually describe subsets of organic brain syndrome; they are not synonyms. A patient with severe cerebral insufficiency due to a febrile condition such as meningitis, or a poison (such as bromides, now a rarity), is said to be both toxic and psychotic and hence to have a toxic psychosis. "Nontoxic" patients (i.e., those not afflicted by an exogenous toxin) may have a cerebral milieu metabolically hostile to the normal function of the cerebral cortex as in hypoxia, hypoglycemia, and so on; thus, they are said to have a metabolic encephalopathy. Sometimes an electroencephalogram (EEG) from such a patient will have the characteristic diffuse slowing of the background rhythm and will be diagnosed as metabolic encephalopathy or metabolic dysrhythmia.

If the acute form of the syndrome (e.g., due to hypoglycemia) is not recognized and treated, the patient may develop the chronic form of the disease, although many persons with the chronic form have etiologies (discussed later) that may never show an acute phase and are believed to be irreversible (e.g., Alzheimer disease).

Chronic Organic Brain Syndrome (Dementia)

The chronic form of cerebral insufficiency has been variously called chronic brain syndrome, chronic organic brain syndrome, chronic organic mental syndrome, or dementia. I prefer the last term, although some authors maintain that the term *dementia* has been tainted by the perception that dementia is by definition irreversible. Actually, a good percentage of the dementias are reversible, as discussed further in Chapter 26.

Please note that both the acute and chronic forms imply the loss of function previously available. If a patient is mentally retarded from birth, his examination findings may be similar to those of a patient with dementia, but the term is not applied in this case. Conversely, one should be very careful not to diagnose mental retardation in a patient suffering from a reversible acute brain syndrome.

Examination for Organic Brain Syndrome

Again, this examination is actually the cognitive portion of the mental status examination, which is performed out of sequence and is possibly written up out of sequence for those whose case record forms contain a statement of "patient reliability" on the first page.

Examination for Disorientation

Types of Disorientation

There are three spheres of orientation: time, place, and person. Some authorities recommend a fourth dimension, called situation, which I do not find useful. Also, it is difficult to teach in that it requires the physician to make some rather sophisticated judgments about the patient's ego defenses. For example, if a patient cannot tell the doctor the specific medical circumstances of his hospitalization, it might be because the patient is disoriented to the situation. On the other hand, it might be because previous doctors neglected to inform the patient or because the details are so dismal that the patient is utilizing the ego defense of denial. Or, the patient might not understand the question.

Disorientation develops in a stereotyped sequence. Orientation to time is lost first, followed by orientation to place, and finally to person. When the patient is successfully diagnosed and treated, the orientation returns in the opposite order: First the patient remembers who he is, then he can remember (or be taught) where he is, and finally he can be reoriented to time.

When the patient is disoriented to person—that is, he does not know who he is and cannot even tell the doctor his own name—he is probably in a nearly stuporous condition. Diseases that can cause this state (e.g., severe diffuse lupus cerebritis or multiple staphylococcal brain abscesses) usually have many other findings and do not constitute a diagnostic problem. Dr William Summers of Albuquerque was taught that disorientation to person should mean disorientation to persons close to the patient, for example, misidentifying a spouse as a parent or stranger. This happens late in Alzheimer disease long after a patient loses orientation to time and place.

We refer to teaching the patient where he is and to reorienting him in the dimension of time because if the patient is found unconscious in the streets and revived in the hospital, it is unreasonable to expect him to know where he is or how many days have elapsed unless someone tells him. For this reason, every patient who is disoriented should be reoriented to the correct place and date, which should be noted in the case record. Patients who are slowly recovering from their cerebral insufficiency may pass through a phase of intermittent disorientation.

Checking for Orientation in Time

Simply ask the patient to tell you the day of the month, the name of the month, and the year.

This is easy to say but sometimes difficult to perform. But remember, this is part of the physical examination. Although one is "only" talking to the patient, one is checking a very specific point and must be as tenacious as one is in the search for an important diastolic murmur. This is not an open-ended interview question, a historic review-of-systems question, or a social chat. It is a critical part of the physical examination.

Students sometimes feel awkward about this point, but then they also feel awkward about doing rectal examinations. The student should consider the consequence of missing a possibly reversible brain syndrome. The patient whose feelings were supposedly being spared might remain undiagnosed and untreated and, as a result, live out his days in a state mental institution in a vegetative state. Those who believe that this does not happen should peruse Chapter 26.

Some persons like to look up at the patient when they are recording this material and ask the patient the date as if they, the historians, do not know the correct date. This sometimes works, but an evasive patient might turn to a patient in another bed and ask him. And there are many other questions in the cognitive examination, so I tend to

explain what I am doing: "I'm going to ask you a lot of questions now. Some you will know the answer to and some you won't. Just answer the ones you can." It is better to be straightforward. Even the patient with dementia might be able to perceive a subterfuge.

Some persons only ask the patient his birth date and then compare it with his stated age. This device gives a few false positives and many false negatives. Because we desire screening tests to have some false positives, but no false negatives, this technique is not recommended. I have heard a skillful attending physician ask patients directly, "You've been having a little trouble with your memory lately, haven't you?" with an accepting smile and in a tone of voice that gives patients permission to report the problem. The less confident neophyte has difficulty with this approach.

I require that the patient knows the year, the month, and the exact day, in order to be called oriented. Now, many persons, including me, pay no attention to the day of the month, and so are technically disoriented to time. This does not mean that they necessarily have an organic brain syndrome, but they have failed the screen, and the examiner must proceed to further testing (*vide infra*). The point to be emphasized is that one can accept false positives with a screening test but no false negatives. Thus, the patient must give the correct year (even on January 1), the correct name of the month (not "Christmas" month because the patient has noticed the hallway decorations), and the exact correct day of the month (not weekday name), not even missing by a single day.

False Positives for Disorientation in Time

In addition to normal persons who simply do not attend to the date, there are other patients who commonly do not know the exact date. First, there are very severe schizophrenics. While most schizophrenics are oriented to time, some are either disoriented or so disturbed that they cannot cooperate with the testing. Some patients with very severe depression are likewise unable to give the date, but it is not always clear whether they are truly disoriented or simply unable to cooperate. A severely excited manic patient may have so much tangentiality[1] and pressure of speech that he cannot answer the question. Patients suffering from any of the Freudian dissociative states may be unable to answer. This category includes Ganser syndrome, which is seen in prisoners and inmates of other institutions. Whatever the cause, patients with Ganser syndrome always answer incorrectly and thus appear disoriented. However, they would also answer "four" to the question, "How many legs on a three-legged stool?" (Thus, they are easy to diagnose, if not to treat.) I have also seen patients who were either malingering or suffering from a hysterical conversion reaction who appeared disoriented on direct questioning. Finally, patients suffering from sensory deprivation will be disoriented to time, regardless of whether the deprivation is experimental, political, or nosocomial (as in patients who are immobilized without vision after retinal surgery, or who are placed in intensive care units without light, time, or calendar cues). All of these false positives can be easily diagnosed on affirmative grounds by a competent clinician.

False Negatives for Disorientation in Time

If the patient with dementia notices that his physicians have taken a very strong interest in his ability to recall the date, he may take some steps to satisfy what he perceives as their wish. For instance, some disoriented patients who have been repeatedly asked about temporal orientation learn to read the date from the physician's calendar watch. Others will keep a newspaper or hospital menu at their bedside table so that they can glance at the date when asked.

One patient who was described as completely oriented put the date 3 days in the future when I examined him. (Most disoriented patients put the date in the past.) When I examined the examiners, I was told that his answer was always exactly 3 days in the future, leading someone to conclude (erroneously) that he really was oriented and did not need to be reoriented. Further investigation revealed that the patient realized that his doctors were interested in the date. Accordingly, he daily removed his milk container from his breakfast tray and placed it on his nightstand. Each time he was checked for orientation in time, he read the milk's expiration date from the container. As is so often true in medicine, awareness of the problem may be the solution.

Summary

If the patient is oriented to time, I may not do any more of the cognitive portion of the mental status examination at this point in the interview, unless there is reason to suspect one of the rare false negatives. But if the test is positive, I proceed to the rest of the cognitive examination, until I am convinced one way or the other.

Checking for Orientation in Place

This test is useful when the patient is obviously disoriented and thinks he is at home or in an airplane. But it is not a very good screening test. Many false positives occur if one is very rigid and requires a perfect answer for the name of the hospital. Some patients may know it is a veterans hospital but are unable to give the specific name. Or they may know the name of the city, which is often a partly correct answer for certain hospitals but, as in the case of the veterans hospital, an incomplete one. If the name of the hospital has changed, the patient may only know the former name. Worse, there are false negatives. Some patients with cerebral insufficiency still know the name of the hospital. Accordingly, I do not use this question often, usually proceeding directly to a test of calculation.

Examination for Ability to Calculate

Performing the Serial Sevens Test

The traditional standard test, which may be problematic for persons educated in American public elementary schools after 1960 or so (see "false positives"), is called "serial sevens" because the patient is asked to serially subtract seven from the residual of each operation. It is traditional to begin with the number 100. It goes like this:

Physician: "Can you take 7 from 100?"
Patient: "Yes, I guess so."

[1] *Tangentiality* refers to the habit of changing the subject of speech by moving gradually away from it, at a tangent, and never coming back to it. It may be distinguished from circumstantiality, which is used to mean either (1) dealing with the subject in great detail or (2) circling around the subject and eventually returning to it.

Physician: "Go ahead."
Patient: "You mean 100 minus 7?"
Physician: "Yes."
Patient: "… That's 93."
Physician: "And 7 from that?"
Patient: "… 86."
Physician: "Minus 7?"
Patient: "… 79."
Physician: "Minus 7?"
Patient: "Uh, … 72."
Physician: "Keep going. Seven from that?" (Note that you should not help the patient by reminding him of the last number. The ability to remember that number is part of the test.)
Patient: "Uh, 65 … uh, 58 … 51 …," and so on.

Such a patient is said to be able to do serial sevens.

Validation studies done during World War II in California revealed that sixth-grade school children could subtract all the way down from 100, with correction of their mistakes, in under 2 minutes (Hayman, 1941). This suggests that timed daily serial sevens could be used to follow the progress of a given patient. However, if you do that, remember to start from a different number each day, because the practice effect can permit a cognitively impaired patient to learn the right answers just as a visually impaired patient can learn the letters on the eye chart. For example, on the second day, start with 102, the third day with 105, and so on.

A Teaching Trick

If you doubt that a patient can "learn" serial sevens, do the following experiment: Test the patient twice daily, once with different starting numbers and once from the same starting number (usually 100). Make the same measurements—the number of errors and seconds required to complete the test. If you use the same prompting rules (no correction of errors and no encouragement to "go ahead and try"), there will eventually be a divergence in the results, even with testing only twice a day, unless the patient is recovering rapidly.

In contemporary use, the mistakes are not corrected, to allow us the opportunity to observe perseveration (e.g., "93, 90, 83, 80, 73, 70," etc.) on the part of some patients with dementia. However, many patients with dementia will not perseverate.

Most normal subjects will do serial sevens without a mistake or with only one mistake in the first six subtractions. Two mistakes out of the first six are indeterminate, although it almost always implies a mild degree of cerebral impairment. But three or more mistakes out of the first six, or an inability to continue, is a reliable sign of organic brain syndrome.

Some patients are unable to finish the serial sevens, even with errors. The neophyte may feel embarrassed for the patient. The situation is best handled by smiling at the patient even when he fails the task. Your attitude should be, "Maybe you can't do that test right now, but you were a good chap for showing me that you couldn't do it, and now that I have that piece of information, I will be more able to help you. I am your friend." You might actually say something reassuring to the patient, such as, "I don't really expect anyone to be able to complete all these tasks, but I want to see how many of them you can do."

If you think in your own mind that none of these tests are very important in measuring the worth of the patient as a human being, you will find that your instructions convey your acceptance of the patient no matter how well he performs. It will also help you to feel less upset, so that you are not inhibited from doing the test specifically in those situations in which it will be most helpful (i.e., when the patient is most likely to fail).

False Positives

A mentally retarded person or one who left school in the second grade in order to chop cotton may never have had the ability to perform serial sevens. Because the test is intended to detect loss of function, and one cannot lose what one never had, the test is invalid in such a person, who should be identified by the social history. Do not try to compensate by making the test easier, say by asking the patient to perform serial threes, because the normal results have not been determined. Serial fives are worse than useless because the correct answer sounds the same as a perseverating one (95, 90, 85, 80, etc.).

In many American schools, all calculations are performed with an electronic calculator, and many students never learn their "math facts." Ability to do serial sevens is not recommended as a screening test for concussion in high-school athletes because only 52% of a group of 611 uninjured athletes could perform the test successfully (Young et al., 1997). The standard used (completion in less than 1 minute with 7 consecutive correct iterations or 11 correct with one mistake) was more stringent than in the validation study (*vide supra*). An informal preliminary study of persons considered "average-to-good students" showed that all subjects over the age of 40, but only about 70% of those under the age of 25, could perform serial sevens in under 2 minutes with fewer than three errors (J. Orient and J. Stensrud, *personal observations*, 1998).

False Negatives

There should not be any false negatives with a properly performed test.

Examination for Impaired Memory

There are a large number of tests for memory. One can ask the patient to repeat six digits forward or to repeat the last four of the six, going backward. The individual digits should be given slowly, one per second, so that the patient does not make compound numbers out of them.

An alternate method is to give the subject three words to remember and see if he can recall them later in the examination. Or one can ask the subject to remember three numbers. He should be able to recall them after counting aloud slowly from one to ten.

Persons who have never been to school pose special problems, and special psychometric tests are available for them. A good test is to ask the patient to say the days of the week or months of the year backward. Patients without an organic brain syndrome can always do this, regardless of the level of schooling, in my experience. (In the study of high-school athletes referenced above, 90% of the subjects could correctly name the months of the year backward in <1 minute.)

At this point, you should be able to tell whether a person who is disoriented to time has an organic brain syndrome. If you are still having difficulty, you may wish to consider the following additional features of cerebral insufficiency, both acute and chronic.

Testing for Impaired Judgment and Abstracting Ability

Examples of questions that test for judgment are: "What would you do if you found an addressed envelope on the sidewalk and it had an uncanceled stamp on it?" Or, "What would you do if you were in a theater and noticed a fire?"

To test for abstracting ability, one can ask for the interpretation of proverbs such as "a stitch in time saves nine" or "a rolling stone gathers no moss." Alternately, one can ask how things are alike, such as an apple and a pear, or a penny and a dime. Or, one can ask which item does not fit in a group—for example, an orange, a nickel, and a banana.

These questions are also good for examining the examiners. Some people have accepted "banana" as the correct response to the last question, reasoning that the other two are round; an example of a concrete response. Similarly, a patient who gave an abnormal concrete interpretation of the proverb ("a rolling stone will never get green") was judged cognitively normal by one examiner.

Other Tests

There are a large number of structured, scorable evaluations of the cognitive portion of the mental status examination. Of these, I recommend the Jacobs test, which was developed for use with medically ill patients (Jacobs et al., 1977), or the "Mini-Mental State Examination" (MMSE), which has been extensively validated (Folstein et al., 1975). A distribution of scores by age and educational level is available for this test (Crum et al., 1993), along with tables relating the posttest probability of an organic brain syndrome to score and pretest probability (Meiran et al., 1996). The test I use, which is similar, is found in Appendix 2.1. This screening instrument will probably fare no better than any of the established ones, all of which are imperfect in certain circumstances (Nelson et al., 1986). In particular, the MMSE has been criticized because performance is heavily influenced by culture and education and because of lack of sensitivity in patients with frontal-type dementia or cognitive impairment due to major depression or schizophrenia. For such diagnoses, other measures such as the executive interview (EXIT) or the qualitative evaluation of dementia may be superior (Royall et al., 1993, 1995). The EXIT test will be described in Chapter 26.

The EEG, actually a laboratory test, may be of value. In acute cerebral insufficiency, the EEG will show a slowing of the background rhythm compared with the premorbid tracing. Unfortunately, it is of little use if there is no premorbid tracing available. Furthermore, in some patients with chronic dementia, the abnormal cells that generate the slowed rhythm may die, so this diagnostic sign will no longer be present.

A number of psychologic tests may be available to the examiner. The Bender Gestalt test, for which scoring systems are available, is excellent. In the past, I carried the last card of the Bender Gestalt test in my bag because the inability to draw the two superimposed polyhedra after viewing them was an efficient (positive) test for dementia. (The test is also sensitive; the ability to copy the design accurately from memory is good evidence against dementia.) Because some certified psychologists objected to this, on the grounds that I lacked the proper wall hangings, I discontinued the practice on the advice of my lawyer.

An alternate test is to draw two intersecting pentagons at least 1 in. on a side and ask the patient to copy it. All ten angles must be present, and at least two must intersect to be counted correct, but rotation and tremor are to be ignored (Folstein et al., 1975). The drawings may be placed in the case record for making future comparisons. Another test of visuoconstructional abilities, along with numeric and verbal memory, that lends itself to comparison over time is the Clock Drawing test (see Chapter 26).

Self-test

Write down three reasons why you would want to identify the patient with dementia as soon as possible. (Appendix 2.2.)

For the Attending. One of the major problems in teaching the approach described above is the high opinion that the jejune (of all ages) have of their own diagnostic abilities. They are all convinced that if there were any cognitive impairment in their patients they would surely pick it up without specifically testing for orientation. Unfortunately, the only guaranteed way to dissuade them is to interview some of their own dementia patients whom they thought "seemed okay to me." Even this does not always work the first time because the illegitimately secure will always rebut, "He must have gotten this way in the last 24 hours." I have even tried playing a tape-recorded genuine (unstaged) interview of such a putatively "oriented" patient, who on direct questioning was disoriented by 20 years (see Chapter 26), only to find on follow-up that members of that laughing audience were still making the same mistakes a year or two later. Ben Hecht's description of John Barrymore's "last performance" is probably the most dramatic example of how a person with a known severe dementia can deceive keen but uneducated observers (Hecht, 1985).

Approach to the Elderly Patient

The most important thing to remember about elderly people is that patients over the age of 79 years may still "see" themselves as 39. I am not speaking of demented patients but of normal people. In my experience, this is probably even an understatement. A 79 year old may see himself as 59, 39, 19, or sometimes all three in the course of one interview. The problem is that the interviewer has difficulty seeing the 79-year-old patient as a 19 year old. And, whereas the physician has experience with many 79 year olds, the patient has only recently become 79 and that too for the very first time. Thus, it is a novel experience for him, and he must fall back on prior experiences in order to cope, just as you will fall back on critical educational experiences from your youth in times of medical crisis.

For the Attending. A unique question to have a medical student or young resident ask the older patient is this: "Mr. Smith, when you were the age that I am now, what did you think your life would be like when you got to be the age you are now?" The young interviewer should be instructed to remain silent for 30 seconds after any verbal interaction required to clarify the question for the patient.

The main purpose of this exercise is to promote empathy, as well as to broaden the education of the young physician. For example, a patient whose present socioeconomic situation is different from

that of the resident will often surprise the resident by revealing that his own aspirations and hopes were at one time the same as those currently cherished by the resident. Also, some young persons are detached from the old and impoverished whom they must care for as house officers; the younger may feel that the older arrived at their present decrepitude through some basic moral fault, poor planning, or absence of youthful ambition. To learn that things are otherwise may provide the young with a vicarious shared experience and the basis for better patient understanding.

Many patients over the age of 50 are secretly worried about having cancer. If you keep that idea in the back of your mind while doing the initial history and physical, you will be able to listen perceptively to the patient's fears. You can test this belief by asking a direct (but not a leading) question about what the patient is afraid you will discover, reassuring the patient, when appropriate (Sapira, 1972), and observing what happens. Sometimes, when you wish to reassure patients about what appears to be free-floating anxiety, you can ask about their fears; sometimes the anxiety is not as free-floating as initially believed. The patients will be impressed that such a jejune-appearing person could have perceived their innermost thoughts, and they may attribute to you great qualities of intellect and sensitivity, as a result of your using this simple technique.

This reasonable and ubiquitous, albeit unspoken, concern about cancer is to be distinguished from *cancerophobia*, which is an unusual psychiatric disorder encountered more commonly in the offices of internists than of psychiatrists. It is characterized by a conviction on the part of the patient that he has or shortly will develop a noxious cancer. Furthermore, either this cancer is producing no symptoms (and must therefore be vigorously sought before it gets bigger) or it is producing symptoms whose significance the patient feels is unappreciated by his doctors. Either the doctor is not taking the symptoms as seriously as the patient feels he should or his searching techniques are in some way defective because the cancer remains undetected. Some patients seem to think that their cancers come and go, so the search may be extended for several years.

The Patient Who Seems to Be Changing His Story

When the patient seems to be changing his story, there are several possible explanations:

1. The interviewer-historian may not be very good. He may have confused, misled, or misunderstood the patient.
2. If there are several mediocre interviewer-historians, they may be spending more time conversing with each other than with the patient.
3. The patient may be mentally retarded or demented and simply be unable to remember, while attempting to be cooperative.
4. The patient may be overly cooperative because he does not understand that the history is intended to generate information that will determine the specifics of his treatment. He may believe (especially in county, city, and other governmental hospitals) that the interview is for the purpose of determining whether he will receive any medical care at all.
5. The patient may be changing his story for a motivation that no one can figure out. This rarely happens, and it is a diagnosis of exclusion.
6. The patient is simply inattentive and cannot remember his account without a great deal of review and repetition.
7. The patient is developing a relationship with his doctor that is permitting him to remember or speak about events that were not accessible to him during earlier interviews or that he did not wish to discuss.
8. The patient is suggestible (or has been subjected to some type of pressure) and is saying what he thinks the interviewer wants to hear.
9. The patient may not speak the language well.

Inconsistent answers are not reliable. Hostile attorneys ask the same questions over and over again in an attempt to trap a witness who is lying and has difficulty remembering what lies he has told. But remember, you are conducting an interview, not an interrogation. You are seeking truth in order to help the patient, not to entrap him.

The Patient Who Is Vague

Bracketing and Other Forms of Forced Choice

In attempting to determine the duration or the frequency of a symptom in a patient who is vague, you may find it useful to "bracket" the correct answer by giving the patient extremes to choose from, then reduce the size of the bracket. For instance, if the patient could not tell you the duration of his symptom, you could begin as follows:

Physician: "Was it about a day long or a year long?"
Patient: "Oh it didn't last a year…."
Physician: "Well, was it a day long or a month long?"
Patient: "Oh, I've had it for more than a month …?"
Physician: "Well, can you remember if you had it around Christmas time?"
Patient: "… Now that you mention it, I remember I did have it at Christmas."

In this way, you can eventually narrow the estimate of duration within a range of one or two units of time, say months or days. Even this limited information will often be useful.

Patients frequently have difficulty recounting frequency, especially when suffering symptoms whose frequency varies in a phasic manner in the course of time. Thus

Physician: "Do you get it once a day or once a month?"
Patient: "Well, some days I don't get it at all, but when I get it, it's more than once a day."
Physician: "When you do get it, would it be twice a day or 20 times a day?" (Focusing on frequency per day.)
Patient: "Oh, never 20 times a day."
Physician: "How about ten times a day?"
Patient: "Oh no, just two or three times a day, but a lot of days, I don't get it at all."
Physician: "In an average week, how many days will you be free of the symptom?" (Focusing on asymptomatic periods per unit of time.)
Patient: "Well, last March I would sometimes go several weeks without it. But beginning here lately, I noticed it started coming at least once a week …"

Here, the physician has accomplished the following:

1. Determined how many times a day the patient will have the symptom when he is symptomatic.
2. Approximated the frequency of symptomatic days.
3. Elicited the fact that there has been an increase in the frequency of symptomatic days.

To determine exactly when this last change in frequency occurred, the physician could now proceed as follows:

Physician: "You say that you are having more days with (the symptom). When did you start having more days with (the symptom)?"
Patient: "I'm not sure exactly."
Physician: "Well, did this happen a week ago or a year ago?"
Patient: "Oh, it hasn't been a year. But it has been more than a week…."

The interview continues in a similar manner.

Being Persistent

Some patients are vague in ways that are not susceptible to bracketing or other forms of forced choice. For example:

Physician: "Can you remember how you felt when your mother died?"
Patient: "… I guess I can…."
Physician: "… Well, what did you feel then?"
Patient: "… Oh, I don't know, I guess I don't know."

When confronted with such a frustrating response, it is tempting to change the line of inquiry. This tactic is recommended by many experts, but I disagree. In the desire to get some information, any information, the physician may rapidly slide from one of the seven dimensions to another, never getting a complete database. It is better to persist and give the patient at least three tries at answering the question. At that time, you can change the subject to the difficulty the patient has with answering the question:

Physician: "… I notice that you are having a lot of difficulty talking about how you felt at that time. Why do you suppose that might be?"
Patient: "Now … maybe … uh … you know. I've started wondering lately, well actually, how much did I really like my mother?"

Although one does not often get such a revealing answer, one will never get a revealing answer by sliding off to another dimension or another question without giving the patient a full opportunity to respond.

The Patient Who May Be Addicted to Drugs or Behaviors

The existence of an addiction profoundly affects considerations of diagnosis and treatment. It is important to maintain a high index of suspicion, especially in the emergency room. Alcohol or drugs are involved in a large proportion of admissions to the emergency department because of trauma. It is important to learn of addictions early in the interview because this information, like the assessment of orientation, is relevant to the patient's reliability as well as to the potential risk of a withdrawal syndrome.

Screening for Alcoholism

A number of screening tests have been developed, of which the simplest is the CAGE test for alcoholism. Ask the patient the following four questions: (i) Have you ever felt you should *C*ut down on your drinking? (ii) Have people *A*nnoyed you by criticizing your drinking? (iii) Have you ever felt bad or *G*uilty about your drinking? (iv) Have you ever had a drink first thing in the morning to steady your nerves or get rid of a hangover (*E*ye-opener)?

If the patient gives three or four positive answers, the test is said to be positive (Sackett, 1992).

The CAGE test has been shown to identify nine out of ten alcoholics, whereas the gamma glutamyl transpeptidase, the best of the laboratory tests, detected only one third of those consuming 16 or more drinks per day or who had independently been identified as alcoholic (Ewing, 1984). Though simple and well validated, the CAGE test is underutilized. Alcohol addiction is substantially underdiagnosed, especially in patients who do not look like "typical alcoholics." Remember that denial is a common feature and is probably the mechanism responsible for the annoyance sought in question (ii). Since 25% to 40% of general hospital admission in the US may be related to addiction, a high index of suspicion is indicated (O'Brien, 2008).

The CAGE test, while an effective screening device for lifetime alcohol abuse and/or dependence, is insensitive for detecting heavy drinking and does not distinguish between active and past problem drinking. The AUDIT ten-item questionnaire has been developed but is more difficult to use. The third question on the simplified AUDIT-C questionnaire may serve to screen for heavy drinking in the general medical interview. The question is: "How often in the past year have you had six or more drinks on one occasion?" Any such occasion constitutes a positive screen. A sex-specific modification is suggested because for men, five or more drinks on any occasion is associated with alcohol-related symptoms, while for women, that number is four or more (Bush et al., 1998). (Also see the MAST test in Chapter 26.) Evidence that the full AUDIT test is superior to the AUDIT-C is suggestive but inconclusive (Kriston et al., 2008).

Self-test

The CAGE test has a sensitivity of 51% and a specificity of 99.8%. In a population in which the prevalence of alcoholism is 23%, what are the positive predictive and the negative predictive values? Answer the same questions for a population in which the prevalence of alcoholism is 50% (answers can be found in Appendix 2.3).

Opioid Dependence versus Addiction

The physician must distinguish drug addiction from drug dependence due to chronic pain, and "drug-seeking behavior" from what is better described as "relief-seeking behavior." The distinction is not necessarily easy to make, and mistakes can be made in either direction.

Worrisome drug-related behaviors that are primarily suggestive of undertreated pain, in the view of some pain specialists, include (i) borrowing another patient's drugs, (ii) obtaining prescription drugs from nonmedical sources, (iii) unsanctioned dosage escalations, (iv) aggressive complaining about the need for higher doses, (v) drug hoarding during periods of reduced symptoms, (vi) requesting specific drugs, and (vii) acquisition of similar drugs from medical sources (Fisher, 2004). Physicians should, however,

be aware that this view is controversial. These behaviors are likely to be considered "red flags" by licensure boards and law enforcement, and some are illegal.

More serious behaviors that still suggest undertreated pain but may also indicate other problems, occurring either by themselves or in addition to undertreated pain, are (i) prescription forgery, (ii) stealing another patient's drugs, and (iii) recurrent prescription losses.

If there is a substance-abuse problem, it is important to determine whether the abused substance is an opioid or something else. Often, this does not occur, because of a socially ordained predisposition on the part of physicians to automatically attribute the drug-related behaviors to opioid abuse. Yet other substance-abuse problems have a much higher prevalence in society than opioid abuse. Correctly diagnosing substance abuse is important because a mistaken diagnosis of opioid addiction when another substance is actually to blame may result in the patient being denied pain treatment as well as treatment for the real substance-abuse problem (Fisher, 2004).

Behaviors that indicate with little doubt that opioid abuse is occurring are (i) injection of substances prescribed for oral use, (ii) concurrent use of related illegal drugs, and (iii) selling of prescription drugs. The last may signal addiction or may simply reflect an effort to profit from illegal diversion. A true pain problem may coexist with abuse or diversion (Fisher, 2004).

There is an unfortunate tendency to undertreat pain because chronic pain patients are often stigmatized as addicts and also because licensure boards or law-enforcement agencies may punish physicians severely if they are thought to overprescribe controlled drugs (Orient, 1985, 1994). Listen to your patients with an open mind, and (as should go without saying) treat all patients with respect. Nevertheless, be alert for danger signs, especially if possibly aberrant behaviors persist once an adequate dosage titration has been carried out.

Considerations in Treating Addicts

Let us assume that your patient truly is an addict. It is a good idea to determine, as soon as possible, whether the drug abuse, alcohol use, gambling, philandering, or other problem is ego-syntonic or ego-alien (ego-dystonic). If the behavior is ego-syntonic (i.e., the patient accepts it and does not perceive it as wrong or damaging to himself), one will not expect to bring about a permanent change. If the habit itself (not just its secondary consequences) is ego-alien, one may be more hopeful about change.

To make this determination, simply ask the patient, "Why do you want to stop this?" Most intake interviews do not do this but rather assume that if the patient shows up, he will be "compliant" (see definitions in Chapter 1 for a discussion of this word).

The patient whose behavior is ego-syntonic will give a reason that is contingent upon a specific time, place, situation, noxious outcome, or other temporary factor. For example:

"I don't want to be like that for my daughter's wedding."

"If they catch you doing that in that state, they are very hard on you."

"I told her that if she would, I would too."

"Because now I have to stop until…."

While each of these may be a good reason to change behavior, they will only apply for a limited period. To test the impression that the behavior is ego-syntonic, one could counter each of these reasons with an appropriate rebuttal:

"But what are you going to do after the wedding?"

"What are you planning to do after you pass through there?"

"I guess that if she doesn't, then you won't have to either."

"But then when that's over, I guess you can start all over again."

This probing is not cruel to the patient because it is in his best interest to arrive at an understanding of his true motivation. A covert game involving the patient and the organization offering care wastes the patient's opportunity to change while making the staff cynical. In the long run, it is best for the patient to know his motive and to know that the staff also knows. When he is ready for a genuine change, there is more likely to be a responsive facility available to help him.

Certain habitués are manipulative and will learn to tell each member of the staff what that individual wishes to hear. One drug abuser gave each interviewer a different, highly convincing reason for quitting. He told the student nurse that he wanted to marry a fine girl, after telling the medical student that he wanted to go back to school. The social worker heard that he wanted to take care of his aging parents. The senior resident was told that he wanted to take better care of his health. When an experienced attending interviewed the patient, it became obvious that the drug abuse was ego-syntonic. It should be noted that all of the interviewers who believed the drug abuse to be ego-alien wanted to believe it because the patient was very personable and likeable (Sapira and Cherubin, 1975).

The Patient Who May Be Involved in Illegal Activities

Although one can sometimes omit the introductory explanation about why doctors take histories and ask so many questions (once one can tell which patients are familiar with the procedure), one must always explain the reasons to any patients who might be involved in illegal activities.

Such patients may be met with in jail, or at the hospital prior to being sent to jail, or simply in the hospital after having engaged in an activity that could lead to a jail sentence. Such persons have learned to be very suspicious of those in fiduciary positions, such as lawyers, and those in positions of authority, such as judges and policemen. A doctor may be perceived to be in both categories. To all such patients, I say, "I may ask you about things you do not want to discuss. If I do, then just tell me you don't want to talk about it, and we'll go on to something else. It is more important to have good information to work with, even if it is incomplete, than to have wrong information and make mistakes in your evaluation."

Even this introduction does not guarantee that the interviewer will learn the whole truth. Patients have later approached me (especially when they have been seen in jail) to tell me things they had at first denied.

Whenever I think that a patient, especially one in a private hospital, is seeking sanctuary or is getting "straight" for court appearances, I ask, in the middle of an interview, "When is your court date set?" As I say this, I look at the patient as if I am certain that there is a court appearance approaching, and I am only uncertain about the

date. The patient will inevitably look puzzled and inquire further as to my meaning. I simply repeat the original statement, up to three times.

If the patient does not tell me about the court date, or denies having one, I may tell him that I had the feeling that there was one in the offing because his expectations for care were unusual, given his chief complaint. Sometimes, this produces the desired information. Sometimes, I am simply wrong. Over the years, I have been surprised at how often my intuition has been correct.

If you decide to use this question, drop it unexpectedly into the middle of the interview. Try to restrict it to those in whom the answer is likely to be positive. That judgment is based on intuition; I do not know how to teach it.

The Patient Who May Have Other Legal Involvements

Physicians are increasingly consulted in cases in which the patient's primary motive is not to obtain medical advice but to gain compensation through the legal system, for example, to collect disability payments or an award in a personal injury case. It is helpful for the physician to know this because the court schedule has a profound influence on the prognosis. The patient cannot expect to collect benefits if he improves too much. This knowledge can save the physician considerable frustration.

If you suspect that the record of the visit is likely to be subpoenaed, you must be particularly circumspect about writing down information that should be kept confidential. In addition, you will want to be especially precise about chronology related to the incident that sparked the litigation.

The Pseudopatient

In the peculiarly hostile legal climate at the present time, physicians may encounter "patients" who, on their own or as agents for others, may try to entrap the physician into engaging in illegal or actionable behavior. The consequences could be malpractice liability, antitrust accusations, adverse peer review or quality assurance proceedings, sanctions for privacy violations, or criminal prosecution for inappropriate prescribing of controlled substances or false claims (i.e., any misstatement to any insurer). Such patients may be wearing a "wire" that transmits conversations to a recorder outside the office. This is usually a cord wrapped around the chest or other concealed part of the body, with a small transmitter attached. Such a device produces a better quality recording than simply wearing a tape recorder and provides a witness to authenticate the source.

Known examples include a patient who was seeking support for a malpractice claim and law-enforcement agents seeking evidence of prescriptions "not in the legitimate course of medical practice." (If the patient is lying about symptoms, the prescription may be judged illegitimate.) Some undercover agents have posed as patients for years. One coyly refused to give a number representing severity of his pain on a visual analog scale and tricked a physician and her staff into suggesting and recording a number.

Some physicians have purchased radio-frequency detectors such as the one shown in Fig. 2-2 to protect themselves and the confidentiality of other patients in the office whose conversations may also be secretly recorded. Cellular telephones interfere, but the signal they transmit is intermittent.

Of course, physicians should not need the threat of prosecution to remind them to exercise a professional demeanor and discretion in all their communications.

The Patient Who Might Have a Factitious Disease

Autogenic illness (e.g., Munchausen syndrome) is sometimes the final diagnosis in a patient with a complex and puzzling story. The interviewer whose mental status examination goes beyond "oriented times three" and who does more than a perfunctory "coffee, tea, or milk" social history may suspect this diagnosis during the first interview.

An interactional style characterized by "truculence and evasiveness" has been described in patients with Munchausen syndrome (Ireland et al., 1967). The patient's affect may not be immediately appropriate to the verbal content of the interview. There may be self-contradictions within the historic material, and the patient may try to avoid discussing any one aspect of the past medical history in depth. The failure of all attempts to locate family members at the given addresses and telephone numbers is a "positive" diagnostic

Figure 2-2 A radio-frequency detector.

sign, said to be highly sensitive for the pseudologia phantastica variant of Munchausen syndrome (Sapira, 1981).

When the diagnosis of any autogenic illness has been established, it has been suggested that the patient should be gently confronted by the internist in the presence of the psychiatrist, who can then initiate a relationship in a supportive, nonjudgmental manner. My approach has been to initiate psychiatric consultation from the beginning, regardless of the issue of confrontation. First of all, not all physicians are capable of participating in direct confrontation in a gentle manner, especially after they have been through a diagnostic wild goose chase. Furthermore, if one views the patient's total behavior as a biologic event, one can quickly formulate a hypothesis (usually affirmed later) that this specific pathologic behavior is, for the time, the patient's only way of communicating an intense distress. If so, it may be impossible for the patient to "confess" when confronted, and usually such patients do not "confess." Even if they do, that is no guarantee that the behavior will cease. There is always another doctor and another hospital. Therefore, one would wish to initiate the patient–psychiatrist therapeutic alliance independent of the presenting illness and before any confrontations. The psychotherapeutic process would presumably broaden the patient's repertoire of coping responses beyond the production of autogenic disease.

Almost all "medical" patients have some underlying psychopathology—at the very least, life's everyday unhappiness and problems—about which they will gladly unburden themselves if given the opportunity. A psychiatric consultation can be presented as an "opportunity" to assess the consultant's ability to help resolve the patient's personal problems, independent of the internist's diagnostic evaluation, which will proceed pari passu.

After diagnostic closure, the internist may confront the patient, or he may simply tell the patient, in a nonaccusatory manner, as in the case of a warfarin eater, "We found some warfarin in your blood on admission, but its effects are all gone now. This condition should not recur." In the event of an angry or accusatory confrontation, it is advantageous for the patient to have a preestablished patient relationship with a consultant, not related to the subject of the diagnostic physician's anger (Sapira, 1981).

Sexual Orientation

It is often important to determine not only the patient's sexual orientation(s) but also his sexual behavior with various types of partners. I ask, "With whom do you like to have sex?" and wait for an answer. Some patients become confused by this question, to which they believe the answer should be obvious, so one can add, "Do you prefer men or women as sexual partners, or both?" Watch the patient's eyes during these questions. Some distrustful patients will break eye contact or flick their glance down at your pen and up again if you have not earned their confidence. Patients who are worried about their sexual orientation, but who are not yet active, may also respond in this way. (Of course, generalizations such as the correlation between good eye contact and truthfulness are not perfect but are simply reminders of (a) the importance of observing nonverbal behavior and (b) the potential effect of social forces on historic responses.)

Next, I ask how active they are sexually at the present time and possibly when they were last sexually active. Then I inquire about the specific descriptions of behavior if this is important.

Recording this information in a manner that preserves confidentiality is covered in Chapter 4.

The Patient Who Is a Member of a Subculture with Its Own Jargon

The single principle to be observed with a patient of this description is not to use the individual's language unless it is completely natural to you. This is especially true of the language of the criminal, drug-abusing, or juvenile subcultures. Remember that language serves a protective function. Permit the patient to maintain that protection, or he will have to achieve it in some other way.

Many recognize the protective function of language but assume that if they show themselves to be cognoscenti, or even if they show their interest by trying to "get into" the language, the patient's natural cautions will disappear. In fact, the contrary is the case.

Once the patient has sufficiently assessed you and decided to accept you as a physician, he will not need to hide behind the mask of his argot.

There are certain obvious situations in which it may be in everyone's interest to violate the rule. For example, the physician who sees a patient in the emergency room for a stab wound needs to know whether the patient has been "juked" or "stobbed," to help assess which internal organs are likely to be involved. (The assailant's knife points up in "juking" and down in "stobbing.") If the patient uses unfamiliar terminology, the physician must ask its meaning if he is not sure he understands it.

The Non–English-speaking Patient

In some hospitals, the social service department keeps a list of translators available. When using a translator, especially a member of the patient's family, special care must be taken to preserve the patient's privacy, by swearing the translator to secrecy. The translator is never to reveal anything that he hears to anyone, and he is never to speak of it again. He may be asked to lift his hand as in taking an oath, as well as to translate the exchange for the patient. By watching the patient, especially his eyes, during the translation, you can often perceive whether the patient has completely accepted the translator or not.

You should address your remarks to the patient, not to the translator, because sometimes the patient will understand part of what you say, and you will be better able to read the patient's nonverbal messages if you are looking at him directly.

The biggest problem in my personal experience has been the patient who speaks a little English, enough to carry on a conversation, but who does not have sufficient vocabulary to get through a review of systems. In this instance, the patient may agree to statements that he does not fully understand in order to please the physician. As always, it is better to have incomplete information than wrong information. Stating the same question in several different ways at different points in the interview (in order to be sure you

have consistent answers) may be helpful. (This technique is also good for English-speaking patients because it is surprising how often the patient has not understood a question but has answered it anyway.)

If you work in an area where there are large numbers of patients who speak a certain language, learning a little of the language may help in building rapport because it shows patients that you are interested in them. If the language is Spanish, numerous aids are available.

A database form for the Spanish-speaking patient is given in Appendix 4.1. *Southwestern Medical Dictionary: Spanish-English, English-Spanish* by Margarita Artschwager Kay (University of Arizona Press, Tucson, 2001) is especially good because it includes idiomatic expressions. The *Spanish-English English-Spanish Medical Dictionary* by Onyria Herrera McElroy and Lola L. Grabb (Lippincott Williams & Wilkins, 2005) contains a small amount of grammar; lists of abbreviations in Spanish and English; weights and measures; and tables of common symptoms, instructions for patients, or general questions for the medical history.

The Patient Who Cannot Hear Well

The patient may be able to hear better if you place your stethoscope's earpieces in his ears and speak through the bell. This method was invented by Laënnec.

Your tape-recording equipment can be useful here if the patient does not have an adequate hearing aid but can benefit from amplification. Place the earpiece in the patient's ear or, better still, use stereo earphones, because these also help block ambient noise. Speak into the microphone yourself. With the machine set on "record," its amplifier will serve as a hearing aid for the patient. It is easier to speak in a civil tone when you do not have to speak loudly to enable the patient to hear. If there is not a tape in the machine, it can still be used in this manner by pushing "eject," then depressing the "record" lever.

In any situation involving hearing impairment, it is useful to attempt not to raise the pitch of your voice as you increase the volume. Many persons have a greater loss for high-frequency tones than for middle- and low-frequency tones. If one follows the natural instinct to shout at a higher frequency, the gain in volume may be offset by the move into a frequency range at which the patient's hearing is more severely impaired.

If the patient is completely deaf, one can take the history using a computer (formerly a typewriter was used), letting the patient also type in his answers if he prefers. This lengthens the interview but not as much as you might think, provided that the patient is not also visually or cognitively impaired. Admittedly, the review-of-systems portion of the interview can be quite boring, and this is one of the few situations in which I would gladly use a printed form.

The Patient Who Cannot Read Well

While more and more written instructions are produced for patients, nearly half of the patients cannot read or understand much of the information. The problem is not restricted to immigrants. According to the National Adult Literacy Survey, 1992, 21% of Americans are functionally illiterate and read at or below a fifth-grade level. An additional 25% are only marginally literate. Functional health literacy, such as the ability to read prescription bottles and appointment slips, may be worse. A publication from the largest professional liability insurer in Arizona recommends creating a "shame-free" environment in which low-literate (or vision-impaired) patients can seek help without feeling stigmatized. Any instructions should be written in very simple language (MICA, 2003).

What does this tell you about exclusive reliance on preprinted forms to obtain a medical history?

The Hostile Patient

Quite often, one will become aware at the beginning of the interview that the patient is very hostile. Sometimes, the patient seems specifically angry with the interviewer. One method of handling this situation is simply to say to the patient: "Gosh, Mr. Smith, you seem awfully angry, yet you can't be angry with me because we have never met before. What has upset you?"

It may develop that the patient is upset because his lunch tray was late. Or he may have been treated in a demeaning manner in the admitting area. Perhaps he may be reacting to some other frustration that preceded your entrance into the room. Of course, if the patient starts out in a good mood but becomes angry in mid-interview, it may well be that you have induced the hostility in some manner. In that case, it is a good idea to stop the interview and ask the question above. By finding out what you did that was offensive and dealing with it in a considerate manner, you can reestablish rapport in the interview.

The Patient Who Refers to Himself as a "Guinea Pig"

Patients often refer to themselves as "guinea pigs," especially when they are in a teaching hospital. In dealing with this perception, one must first determine what the term *guinea pig* means to the patient. Probably the best way to do that is to ask the patient. (The concept of ego-syntonicity can be applied here.)

If the patient feels that he is the object of experimentation, with no benefit to him (as in a drug study), or that he is being used for education of students and house staff, again with no personal benefit, then the use of the phrase is clearly pejorative. In that case, one must dispel the patient's fantasies; if the perceptions are accurate, one must help free the patient from the situation.

On the other hand, some patients who were the first in their city or the first in a given hospital to have a certain experience are very proud of this. In this case, the term *guinea pig* is not pejorative but complimentary, or at least indicative of a psychologic situation wherein the patient may gain some sense of mastery of an otherwise noxious circumstance.

In fact, most of the time the phrase *guinea pig* has both connotations; in other words, the patient feels ambivalent. Here one should, as best as one can, "align oneself with the patient's ego" and support the positive meaning of the word while dealing (as above) with the negative.

The Patient Who Will Only Be Examined by a "Real Doctor"

It is tempting for the resident to show solidarity with the team and to reject in turn the patient's rejection of the student or the intern. However, it is better to defer making any kind of response until one has assessed exactly what is conditioning the patient's behavior, which is in no way concerned with the specifics of his care but rather with the age of those who will provide his care. Sometimes, it is the patient's way of distracting his own attention from more frightening problems. At other times, it is a reflection of prior feelings, which he was unable to express (or perhaps unable even to experience at a conscious level) while he was in the situation that elicited them. (For example, they might have been feelings such as anger, resentment, or envy, which were unacceptable to that particular patient's makeup.) Sometimes the patient is angry at a specialist upon whom he feels very dependent. Because he cannot express his anger at the specialist, he may displace it onto more acceptable targets (e.g., on house staff members who are like such a specialist but not in a preexisting dominant relationship to the patient).

The above is an example of the set of transference relationships, which are ubiquitous in clinical medicine, although generally discussed only in the context of psychiatric interviews (MacKinnon and Michels, 1971). In the example, the transference is negative, in terms of its predominant affective tone. Often, the physician is inclined to respond with a countertransference, a relationship that flows from physician to patient. For instance, if a patient who refused to let the intern examine him reminded the supervising resident of one of the resident's past relationships, and if the resident reacted to the patient noxiously but within the rules of that prior relationship (as if the patient were the other person in that relationship), then we would say that the resident had a negative countertransference to the patient.

Positive countertransference (where "positive" again refers to the affective tone) can be just as neurotic and destructive as the negative type. For instance, if a patient experiences a positive transference to the physician and attempts to seduce him, the physician might allow her to succeed if he is having a positive countertransference. Yet, the outcome for the patient–physician relationship might ultimately not be "positive," either in terms of predominant mood tone or the achievement of therapeutic goals.

The Patient Who Asks Personal Questions

Questions about the interviewer's personal life may involve several different types of transference, or they simply may reveal concern about the interviewer's ability to understand or help the patient. Experienced interviewers generally recognize the meaning of the question, and they know when it is best simply to answer it directly, but beginners are generally advised to inquire of the patient, "What did you have in mind?" or "What leads to your question?" Sometimes the interviewer may want to try to interpret the meaning of the question for the patient: "Perhaps you ask about my age because you're not sure I'll be competent to help you?"

Patients who attempt to socialize should be tactfully discouraged, by saying something like this: "I'm your doctor. If we had a social relationship, my objectivity would be lost."

The Organ Recital (or "by the Way, Doctor…")

Quite often in the outpatient practice of chronic disease medicine, the patient asks you about an organ other than the one you had been attending to, just as he has his hand on the door to leave and just as you are getting the chart ready for the next patient.

For example:

Physician: "… and I will give you an appointment for 3 months, so that we can be sure that your blood pressure is under good control."
Patient (rising to leave): "Thank you, doctor."
Physician (signing his note and filing the chart): "Any time."
Patient (reaching the door): "… What about my shortness of breath?"
Physician (looking up, startled): "What shortness of breath?"
Patient: "I get shortness of breath."
Physician (flustered): "Shortness of breath! You never told me about that."

Although patients may switch from organ to organ (hence the name "organ recital"), some patients stay within one organ system, alternating symptoms. Some describe the syndrome in this way: "As soon as one thing is fixed, something else goes wrong."

Like most syndromes, this one has multiple etiologies. One of the most common is a failure of the physician to attend to the patient as a person because of an exclusive concern with the patient's various organs. Therefore, in order to deal with this treatable cause, one must return to paying attention to the patient.

One method is to stop near the end of the interview and ask, "Is there anything else you wanted to tell me about or ask me about?" Then wait and let the patient talk for as long as he wants, even if he is talking about psychosocial concerns.

Of course, there are some situations in which that method will not work. It is well worth remembering that the ticket of admission to seeing the doctor is a "complaint." We ourselves speak of the medical skill required to determine the patient's "chief complaint." Most patients would feel very strange about telling a doctor, "I really don't feel too bad, but I am worried about something going on (at home or work) and want somebody I trust to talk it over with." Furthermore, some physicians would be startled by such a request because they have effectively, but unconsciously, trained their patients not to say such things to them. In that situation, the patient has no recourse other than to pause, with his hand on the door (a safe position from which he may escape if he does not get the answer he wants), and try to titillate the doctor back into paying attention to him by offering the doctor something he knows the doctor will respond to: complaints referable to organs.

The Aphasic Patient

For an aphasic patient, one "without speech," the history might have to be constructed from data gathered from old charts and from interviews with the patient's family and friends. The main problem arises when one does not realize that the patient is aphasic and keeps trying to interview the patient when one should give up.

Aphasia is discussed more fully under the neurologic exam, but two "pearls" are worth mentioning at this time.

Do not diagnose aphasia too quickly in the absence of other neurologic findings.

Do not confuse aphasia with dementia, schizophrenia, retarded depression, or dysarthria (the inability to articulate sounds clearly; see Chapter 26).

The Evasive Patient

If an oriented, otherwise cooperative patient withholds information in selected areas of the interview, you should proceed as described below.

Step 1

Ask the patient why he did not tell you what you asked (whether about sexual matters, suicidal ideation, hospitals where he has been, etc.). You must make clear to the patient that you are not simply repeating the query, but rather you are asking a new question, namely, why he will not answer the original query.

Patients will usually make one of three types of response:

A. There may be a logical reason based on fear of what you might do with the information. If their fears are specific but incorrect, you can reassure them. Alternately, their reluctance may be diffuse and nonspecific. For instance, they may wish that you do not make a written or electronic recording of what they say. In that case, you should turn off the tape recorder or put down your pen.
B. The patient may have come to a conclusion based on the assumptions inherent in a delusional system. For instance, the patient may refuse to give you information about sexual activities because of his fear that you might report it to the FBI or the CIA. You should gently undercut any statements that are fantastic; you might assure the patient that you do not work for those organizations but rather that you work for the patient (assuming, of course, that you do). Then you should pursue his system of thought, particularly if he persists in irrational beliefs.
C. The patient may not even be willing to discuss his refusal to answer. In that case, proceed directly to the next step.

Step 2

Ask the patient, "Why have you come here?" This returns the interview to the subject of the original patient–physician relationship because the patient will usually say the visit was for an evaluation, treatment, or relief of a symptom. If the patient is one of the few who give a reason that is inappropriate to and/or discordant with the original chief complaint, this discrepancy should immediately be pointed out and pursued. Most patients, however, will refer to their original reason for coming, which falls into the general category of "I want you to help me with something, doctor." For these patients, proceed to the next step.

Step 3

Tell the patient, "I want to help you, but in order for me to make correct decisions, we have to have correct information on which to base those decisions," or words to that effect. Whatever the other words, the sentence should begin with, "I want to help you, but …" and the second half of the sentence should use the first-person plural, which is grammatically incorrect but psychologically sound. This sentence helps to prevent the consultation from becoming a doctor-versus-patient battle. It reminds the patient that you want to help but that your assistance derives from a mutual, joint, team effort.

(At this point, most patients will give you the requested data and also the real reason for their withholding it in the first place. These reasons should be dealt with at this time as described in Step 1, parts A and B, if appropriate.)

Step 4

A very few patients will still withhold the information. If the specific information does not seem to be critical at this point, you should proceed with the history taking. Upon discovering that they have not been rejected, some patients will later disclose the requested information. However, if the withheld information is critical to the diagnosis and treatment, the patient should be apprised of your opinion in this regard. Then instruct the patient to return to the office in a week to resume the consultation, giving the patient the option of canceling the appointment if he still feels that he cannot trust you. It is essential that this step be carried out tactfully and considerately so that it will not be viewed by the patient as punishment or rejection. For instance, one might explain to the patient, "I can't proceed without this information. I certainly respect your privacy, but I want to do right by you, and in order to do that, I need

Figure 2-3 The tomb of Voodoo Queen Marie of New Orleans. (Photograph courtesy of Charles Mitchell, with permision.)

to have this information. Why don't you come back in a week, and we can continue the consultation at that time. If I were to try to make a decision for you at this point, I am afraid that I would be wasting your time and money, and worse, we might erroneously come to judgments that might not be in your best interest."

Some critics have argued that this technique is not suitable for situations in which there may not be a "next week" (as in the emergency room). What to do then? Part of the medical art is deciding which problems are solvable and which are not; I have no solution for this interviewing problem in the "no next week" situation. However, those who insist on solutions for every problem, or who believe that they can somehow make a correct diagnosis without obtaining the necessary information, must also believe in miracles. For them, I suggest they visit the tomb of the Voodoo Queen Marie of New Orleans, located in the Basin Street Cemetery. A century after her death, the upkeep on this tomb is still maintained by donations from her grateful followers, to whom she has reportedly granted miracles (Fig. 2-3).

The Uncooperative ("Noncompliant") Patient

Is the Patient Taking the Medication?

Numerous studies have shown that outpatient "compliance" with the physician's prescription ranges from 70% to as low as 25% (Blackwell, 1972; DiMatteo, 1994). It is essential for the physician to determine whether a patient is truly taking his medication. If not, this (biologic) event may give useful information about the patient's interaction with his physician but is not to be taken as evidence for any enduring character trait of the patient.

There are a number of strategies that may be employed. It is an unfortunate paradox that they all work best for those physicians who need them least. Before beginning your inquiries, you must seriously and honestly consider how you will react if the patient states that he is not taking his medications. What will you do, say, and feel? Will you view the patient's behavior as an event with past determinants in the patient's life or as a personal affront with past determinants in your own life? If you think that "nonattendance at a scheduled appointment is a first step astray" (Stephenson et al., 1993) and a sign of a potential "noncomplier," the patient will probably sense your attitude.

One way to find out how you really feel about such things is to ask yourself what you did the last time you felt, but did not know, that the patient who said that he was taking his medicines as prescribed was in fact not doing so. Did you simply order drug levels, or did you share your feeling with the patient in a way that opened communications? If the latter, did you come to believe the patient when he stated that he was taking his medications as prescribed, or did you then order a drug level as an opening gambit in cops and robbers (rather than as, possibly, evidence of a problem with the patient's metabolism of the drug)? Remember, if you entered clinical medicine to become a detective, the patient should be your client, not your chief suspect. Nor should you be deceived by those with more experience than you who claim to be able to predict which patients are "compliant." When the issue has been scientifically studied, and the results analyzed for statistical significance, physicians have not been able to predict "compliance," and their ability does not improve with increasing experience. In one study, the physicians' prediction that the patient was not taking his medicine as instructed proved to be erroneous 75% of the time (Mushlin and Appel, 1977)! Others found that the sensitivity of clinical judgment for detecting "noncompliance" was only 10% (Stephenson et al., 1993).

Here are the techniques:

1. *Acknowledgment*

"I know how terribly hard it is to remember to take all those pills every day. How many times a week do you think you have trouble taking all your pills?"

Or: "I know how hard it is to keep taking those pills for your blood pressure when you feel perfectly well. Which of them do you think you skip most often?"

Or: "When you went to visit the family on the Coast last month, I guess you went off your pills. How long after you came back did you start taking the medications again?"

Or: "How can you remember to take your medicine on the weekend?"

Or: "What happened the last time you told one of our doctors that you were not taking every single one of those pills?"

Remember that the purpose of the question is to facilitate communication, not to replicate the tone of a Gestapo interrogation (*vide supra*).

Quite often, none of these questions seems to work at the time. The patient may convince you that he has taken all of his medicines but later will tell you that he has not. Or he may "try you out" by telling about a time with another doctor that he did not take all his medications but could not tell that doctor. In that case, try to learn the patient's fantasies about what the other doctor would have done. This is the patient's chance to tell you about his feelings toward all doctors, including you. The time invested here will pay good dividends later.

2. *A Diary*

Many clever physicians who have their patients keep diaries for diagnostic purposes do not realize that the diary may also be used therapeutically. Ask the patient to keep a diary of all the times that he forgets to take his medicines and bring it in on the next visit. This accomplishes several purposes. First, it makes it legitimate for the patient to tell you that he has not taken his medications. Second, it may decrease the number of skipped doses by requiring the patient to attend to the issue more closely. It is often easier to take a pill than to find the diary and a pencil. Third, it makes the patient a more active participant in his medical care. Finally, it is an expression of trust between doctor and patient.

3. *Sharing the Decision Making*

To empower the patient while using a preventive technique, give the patient a choice of the medications to be prescribed. Give a brief description of their differences and allow him a choice where possible. Most patients will turn the choice over to you again, but at least they will not feel trapped into taking a particular drug. Eliminating this sense of being trapped seems to be very important for some patients.

None of the above are definitive methods comparable to the tricks we use to elicit a subtle heart murmur. All of them can be ruined by the physician's tone of voice or subsequent behavior. They are simply facilitators. How you react to the patient's admission of skipping medications is the most important factor.

Note that none of these techniques involve writing "noncompliance" as a diagnosis on the patient's "problem list." History suggests that such labels are invariably judgmental.

All of these techniques recognize that being in control of the situation is important to the patient.

The term *compliance* should be replaced by *concordance*, according to a report by the Royal Pharmaceutical Society of Great Britain (Mullen, 1997), to reflect a patient-centered view.

The Counterphobic Patient

One type of noncompliant patient of special interest is the one who is engaged in counterphobic behavior. The patient wishes to deny the disease, the illness, the doctor's prognosis, and its significance to him. One way to do this is to stop taking the prescribed medications. When nothing disastrous happens immediately, the behavior works well in helping the patient to deny his illness. However, as in a patient with congestive heart failure, the continued omission of the medication eventually, perhaps 2 weeks later, may result in a hospital admission for what the doctor sees as the same condition. But the counterphobic patient has had two solid weeks of reinforcement of his belief that the original illness is gone and that the doctors were wrong. The new symptoms, therefore, are seen as evidence of a new disease, about whose prognosis the doctors may once again be in error. Obviously, such patients should not be scolded, and threats of a bad prognosis may not frighten them, because they have already proved the physician wrong.

Sometimes a counterphobic tendency will be spontaneously manifested in the interview; the patient will appear to be proud of not taking his medications. But most of the time, the physician must be aware of this possibility and actively look for evidence of this type of behavior.

Dealing with Fantasies

A fantasy is a private, imaginary scenario. If it is conscious, the fantasizer knows that it is imaginary. The fantasy embodies some belief. It is set in the dimension of time, and it may be in the past, present, or future. Those set in the future are the most important for medicine. We all have fantasies; a daydream is one type. But the fantasies of patients that concern us are different from daydreams in several important ways. Daydreams usually have a positive affective tone (e.g., the "day I won the Nobel Prize"). Patients' fantasies often have a negative tone (e.g., "If I let them do a lumbar puncture, I will become paralyzed from the waist down"). Even those with a positive tone may interfere in the patient–physician relationship by bringing in a degree of unreality (e.g., "If I let the doctor do this biopsy, then maybe he will like me enough to give me a special medicine that only he can obtain and that is the only medicine that will keep me alive"). Often, we do not learn of patients' fantasies unless we are particularly good interviewers, or unless they prohibit us from doing something important that we wish to do.

Psychiatrists and others comfortable with projective tests are good at learning of patients' fantasies. Sometimes, as with Rorschach cards, they ask the patient to create a fantasy or they may ask the patient to make three wishes. Many doctors seem uncomfortable with such methods, and for them, the simplest way to learn the fantasy is to ask about it. For example:

"I know that you don't want us to do the lumbar puncture, and I understand that you feel strongly about it. And I know you understand how important it is. I was wondering if you could tell me just what you think a lumbar puncture is?"

Or: "Tell me what you think a lumbar puncture means?"

Or: "Tell me what you think of when you hear the words *lumbar puncture*."

Or: "What have you heard about lumbar punctures?"

In a patient who was reluctant to have a biopsy, you might say, "What kind of thoughts come to mind when you hear about a biopsy like yours?"

Or: "What do you think is going to happen after the biopsy is done?"

Or: "You were dead set against the biopsy yesterday. What made you change your thinking?"

The important thing is to ask the provocative question and get the patient to start talking. Eventually, the fantasy will be produced. Now, you will understand the belief system upon which the patient's conclusion was based and can deal with it openly, in some cases by undercutting it. For example:

"I have never had a patient become paralyzed from the waist down, or any other place for that matter, after a lumbar puncture. In fact, if I thought that could happen to you, I would not have suggested it."

Or: "There are neurologic procedures in which something like that can happen, but this is not one of them. It is true that some people get a temporary headache afterwards, but there is no paralysis."

In this example, the embedded belief system is: "Doctors can hurt you as well as help you; this one might hurt me." While one may not be successful at overcoming the belief and altering the patient's behavior, without getting the fantasy out into the open, one will only be skirmishing at the border.

Physicians have fantasies too. If you find yourself getting angry while interviewing a patient, you might ask yourself which of your fantasies the patient has interfered with. Many times, he has challenged what has been called the *omnipotence fantasy*. Physicians wish to believe that they have powers much greater that those they really do possess, particularly over life and death. (Indeed, these fantasies receive powerful cultural reinforcement.) The patient who dies, or who fails to respond to treatment, may undercut the physician's fantasy of omnipotence, producing a very negative effect, usually in direct proportion to the power of the fantasy's positive effect. Often, these fantasies are not completely conscious but are still powerful motivators of behavior.

The Patient Who Begins to Cry

If the patient begins to cry, this is a signal that indicates that the interview technique was successful in eliciting emotion-laden material in a manner that permitted the patient to express it.

Give the patient a tissue, and permit him to finish crying. Do not abandon the patient either directly by leaving the room or indirectly by letting the crying patient leave while the physician remains in the room.

The Patient Who Is Undiagnosable

Certain patients who are not suffering from hysteria or conversion come to the physician with objective complaints that have eluded diagnosis. (By objective, I mean that the patient reports an event that occurred at a clearly stated time and that the physician can record it.) I wish to indicate clearly that patients do not have imaginary symptoms. (I can do this in the current intellectual climate only by rejecting the Cartesian duality of objective versus subjective.)

With clinical experience, one can often discern at the beginning whether these patients are undiagnosed or undiagnosable. An example of the former is a patient who is suffering from acute intermittent porphyria, a diagnosis that no physician has thought of and confirmed with appropriate laboratory tests. An undiagnosable patient, however, is one whose symptoms are not yet part of any syndrome or disease described in the scientific medical literature. Such patients remind us of the imperfections of science and humble us with the inutility of scientific medicine in their cases. Sometimes, we become angry and call them names, but these names are not collectively or individually a diagnosis, as scientists understand that term.

A Method

1. If, at the end of my history and physical, I am concerned that the patient may be undiagnosable, I say, "I must tell you that of the patients I see in consultation, I am only able to make a diagnosis in about half of them. We doctors are very good at diagnosing bad diseases—that is, diseases that need urgent surgery or strong medicines. But there are many other patients who have symptoms that come and go, in whom we never make a diagnosis."
   Sometimes, with a sophisticated, relaxed, and intelligent patient I might add, "Diagnostic medicine originated in the 19th century from the autopsy table. So, most of the diseases we know about are diseases that are very bad and killed people. But there are many other diseases that we don't know about that don't kill people. Half of the patients I see are in the latter group."
2. I then state, "I am going to order a few laboratory tests and X-rays, but there is a very good possibility that all of these tests will be negative. We can then be sure that you don't have a bad disease that requires surgery or strong medicines. However, if you have one of the mild diseases that doesn't kill people, we may not yet have a test for it and all the tests may come back negative."
3. I then ask, "How do you think you will feel if all of your tests are negative?" Patients' responses to this question are quite revealing and can usually be easily dichotomized. One group of patients will say, "I will be so relieved." Or, "I don't think there is anything wrong; I only came because my (significant other) wanted me to come in." Or, "I won't be surprised; I figured I was just getting old."

   But another type of patient will say verbally and/or visually, "Well, *I know* there is something wrong; why can't you find out?" Or, "Do you have to find out the name of the disease?" Or, "Can't you just give me something?" Or, "How can you be sure it isn't my (organ or disease important to the patient)?"

   Although this problem may seem to be beyond the bounds of a clinical diagnosis chrestomathy, it is important to know what you are going to say at the end of the workup, or else one's clinical examination of such patients can become desultory. Because these patients eventually will contract a disease, at least the one that finally kills them (no one lives forever), one wishes to continue practicing good diagnostic medicine with such patients.

Question: What do you put on the insurance form?

Dr Sapira's Answer: I put down one of the acceptable nondiagnoses such as a psychophysiologic nervous system reaction. I tell the patient that I am going to put such a diagnosis down. If the patient asks what disease she has, I say something like, "Mrs. Smith, you have Smith's disease; you are the only one who has it." This is not said flippantly but in a manner that indicates that the patient does not fit into a pigeonhole and is recognized to be an individual. It can also be a useful statement to make for those patients in whom one is continuing the use of insight therapy.

Dr Orient's Answer: This question is increasingly difficult because many insurers now demand an answer coded to four or five significant digits, an impossible level of specificity for a physician unwilling to state that a square peg fits in a round hole. Misstatements on insurance claims are a federal crime under the Health Insurance Portability and Accountability Act of 1996. You may be able to find a nonspecific symptom code. Some physicians opt out of Medicare and do not file insurance claims, referring insured patients to a professional billing service for assistance if they wish to file their own claims. Many types of treatment are not legitimately covered under many insurance contracts, and most contracts do not allow a sufficient level of confidentiality to permit the physician to address intensely personal concerns. The insurer may demand a copy of the medical record in order to process the claim. Patients should be informed of the side effects of insurance, just as they are told about the risks of treatment, especially when data are entered into a networked computer, as will probably occur even if a paper claim is filed. For example, data obtained from an insurer have been used to identify cancer patients and call in their mortgages.

The Demanding Patient

Some patients pressure the physician with an insistent demand for rapid treatment or laboratory procedures. The physician who has grown in his diagnostic skill and has confidence in his method will usually communicate this to most patients who simply want relief. Other patients, who want to "master" the patient–physician relationship, will not be comforted by the competent physician's communication of security in his diagnostic method but will

attack it. The sequence of diagnostic maneuvers (history, physical examination, laboratory tests) should be explained patiently once. If the request for intervention becomes repetitive, the physician may choose to interpret it as a symptom: "Mr. Smith, you keep asking me for a prescription, but I haven't yet figured out what your diagnosis is. Don't you think I'll be able to find out what is wrong with you?"

The Patient Who Denies the Relevance of Psychologic Factors

Some patients, just like some physicians, are psychologically inept. These patients will deny psychologic factors or simply not see their relevance, even though they may be apparent to others (family members, physicians, and nurses). Because the patient (or his organization) is paying for the physician's services, he is entitled to accept or reject any diagnosis made at any level, and such patient-rejected diagnoses (or connections between life events and illnesses) should not be chronically harped upon by the doctor in a contentious manner.

Appendix 2.1

Abbreviated Cognitive Examination

Orientation (8 Points Maximum)

1. Ask the patient for the date. Whatever scorable items are initially omitted should be specifically sought by prompting for the category but not the answer. Score one point for each correct answer: year, month, day, weekday.
2. Ask the patient for his location, as above. Score one point for each correct answer: state, county, town, hospital.

Memory and Calculation (16 Points Maximum)

3. (Registration). Name three objects (e.g., hat, orange, and watch), taking about 1 second to say each. Have the patient repeat the names of the objects, giving one point for each correct answer. After recording the score, repeat the exercise until he learns all three.
4. Ask the patient to do serial sevens, starting with 103. Score the first five. One point for each correct answer.
5. (Recall). Ask the patients for the three objects learned in No. 3. Score one point for each correct answer.
6. Ask the patient to spell "earth" backward. Score one point for each letter in correct position.

Language (6 Points Maximum)

7. Point to two objects (e.g., a shoe and a pen) and have the patient name them. Score one point for each correct answer.
8. Ask the patient to repeat the sentence, "No ifs, ands, or buts." Score one point if completely correct.
9. Ask the patient to follow a three-stage command: "Pick up this paper, fold it in half, and place it on the nightstand." Score one point for each part done correctly.

Interpretation

Normal persons should be able to score 20 or more out of the 30 possible points. Fewer than 20 points implies that the patient is significantly impaired, either cognitively, linguistically, and/or culturally.

Appendix 2.2

Reasons for Identifying the Patient with Dementia

1. If the syndrome is acute, prompt treatment may be necessary to reverse it.
2. The syndrome is of high prevalence (10% to 40% of medical patients have it at some time during their hospital stay) and is one of the most underdiagnosed conditions in medicine. If the primary doctor misses the diagnosis, it is unlikely to be discovered by an infraspecialist.
3. If you fail to make this diagnosis, you will waste time seeking historic details that the patient simply cannot recall while possibly causing him to feel frustrated and humiliated.

Appendix 2.3

Answer to the Self-test on the Cage Test

Make a 2 × 2 table as shown in Table 1-1. In a population of, say, 1,000 persons, 230 will be alcoholics; 51% of them (117) will have a positive CAGE test and 113 will have a negative test. Of the 770 persons without the disease, 768 (99.8%) will have a negative CAGE test and two will have a positive test.

Disease present		Yes (D+)	No (D–)
Test positive	Yes (T+)	TP = 117	FP = 2
	No (T–)	FN = 113	TN = 768

TP, True positive; FP, False positive; FN, False negative; TN, True negative.

The positive predictive value = TP/(TP + FP) = 98%. The negative predictive value = TN/(TN + FN) = 87%.

Note that although the test "misses" about half the problem drinkers, in this population, the probability that someone with a negative test will be a problem drinker is only about 1.0 to 0.87, or 13%.

In a population of 1,000 in which 50% are alcoholics, 255 of the alcoholics will have a positive test and 245 a negative test. Of the nonalcoholics, 499 will have a negative test and one will have a positive test (assuming that the sensitivity and specificity remain the same). Thus, the positive predictive value is 99.67% and the negative predictive value is only 67%. For further discussion, see Sackett (1992).

Further Reading

Other ways to handle the inherent difficulties in working with patients have been discussed elsewhere (Bird, 1973; Coulehan, 1987; Lipkin, 1987; Stevenson, 1971).

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CHAPTER

3

The History

To consider the sense of a question, consider what an answer to it would look like.

—Ludwig Wittgenstein

Points to Remember:

- The vast majority of diagnoses can be made on the basis of history and are confirmed by physical examination, laboratory studies, and imaging.
- The dimensions of each symptom, which need to be fully described, include time, quantity, location, aggravating factors, relieving factors, quality, setting, associated symptoms, and inconstant factors (color, clarity, consistency, etc.).
- The expert clinician is formulating and testing hypotheses while conducting the interview and formulating the history. Ask yourself: "What is the worst thing this could be?" And when you have made a provisional diagnosis, ask yourself: "What *else* could this be?"
- When the onset or characteristics of the illness seem difficult to define, ask the patient: "When is the last time you can remember feeling perfectly well?"

Importance of the History

For decades, medical students beginning the course in clinical examination were told that 90% of all diagnoses are suggested or made by the history, 90% of the remainder (9% of the total) by the physical examination, and only 1% of the total by the laboratory tests. (The purpose of laboratory tests is to confirm diagnoses already hypothesized on the basis of the history and physical.)

A careful study of competent clinicians (Hampton et al., 1975) reveals that 82% of diagnoses are still made by the history, 9% by the physical examination, and 9% by the laboratory. A later study showed results essentially unchanged: in 76%, the history led to the final diagnosis; in 12%, the physical examination; and in 11%, laboratory findings (Peterson et al., 1992).

The importance of the history is best illustrated by a research project from the Mayo Clinic (Beart and O'Connell, 1983). One hundred sixty-eight patients with carcinoma of the colon were entered into a prospective study comparing the history, physical, and a variety of laboratory tests in detecting recurrent carcinoma. The patients were seen at least every 15 weeks. The most sensitive sign of recurrence turned out to be the history. Of the 48 patients who developed a recurrence, 85% had coughing, abdominal or pelvic pain, a change in bowel habit, rectal bleeding, or malaise before signs of disease appeared on physical examination, radiologic examination, or serial determinations of the carcinoembryonic antigen level.

The fact remains that anyone can order laboratory tests; only a physician can make a diagnosis. The acquisition of the requisite clinical skills cannot be completed in a week, a month, a year, or probably much less than a decade. To achieve the results shown by the British and the Mayo Clinic studies, one must be quite skillful in eliciting and composing the history. The leading symptom must be described in as many dimensions as possible, and the story must be composed in a chronologically organized manner.

The Difference between Facts and Information

Facts are true statements. Information consists of facts arranged in a useful manner.

A history is not simply a collection of facts. It must also contain information, although a good history even goes beyond that. Simply writing down or reciting a gaggle of true statements is not composing a history. The facts must be placed in a form that makes them informative.

Many medical schools "teach" by having students memorize a large number of facts. But, these schools do not teach students how to decide what a fact is or how to collect facts in a useful and informative manner. This method is like teaching a neophyte cabdriver to work in a new city by having him memorize all the names and addresses in the telephone book, instead of showing him how to read a map.

Overview of History of Present Illness

As an aid in composing the history of present illness (HPI), the student needs to have in mind a structure. Figure 3-1 is a handout that has been used for more than 15 years to help students initiate an adequate bedside presentation of the HPI.

Example: An Unacceptable Presentation

"John is an unemployed veteran who is back again for his hypertension. His doctor said that he needs a different medicine. He had something like this once before, but he isn't certain whether it was when he was a little boy or not."

Example: A Satisfactory Presentation

"Mr. Smith is a 42-year-old black man who enters our hospital for the second time with a chief complaint of a 'nosebleed' of about 6 hours duration. The history of the present illness begins 5 years ago when a blood pressure of 180/120 was recorded by a plant physician at the time of a routine preemployment examination.

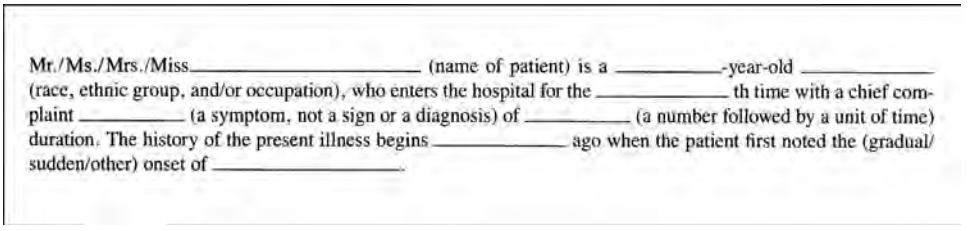
Mr./Ms./Mrs./Miss_____ (name of patient) is a _____-year-old _____ (race, ethnic group, and/or occupation), who enters the hospital for the _____ th time with a chief complaint _____ (a symptom, not a sign or a diagnosis) of _____ (a number followed by a unit of time) duration. The history of the present illness begins _____ ago when the patient first noted the (gradual/sudden/other) onset of _____.

FIGURE 3-1 Form used by students to compose the history of the present illness.

"He sought no medical advice for this and remained asymptomatic until 4 years ago when he noted the gradual onset of headaches, usually but not always pounding, occurring on an average twice a week. There were no aggravating or alleviating factors (other than aspirin), nor any associated symptoms, until 2 years ago, when the headaches became more severe and blurred vision supervened. For this latter reason, he visited our emergency room (ER) and was admitted. At that time, he was also told for the first time that he had blood in his urine, although he himself recalls no change in its color … (etc.)."

Chief Complaint

The chief complaint is a statement (in the patient's own words) of the index symptom that you have selected from the interview material as being chief or principal. Because it is a direct (albeit edited) quotation, it is placed in quotation marks. It is followed by a statement of duration: A number followed by a unit of time (e.g., 1 hour, 2 days, 3 weeks, 4 months, 5 years, etc.). Placing the chief complaint in the patient's words is a device that prevents the inexperienced as well as the senile from placing their own diagnostic conclusions in the database. For instance, a patient who had actually complained of "spitting up blood" was presented as a case of hematemesis. After a protracted and fruitless workup, a consultant quickly discovered the fact that the patient was actually suffering from hemoptysis (see Chapter 16).

The statement of time is a modifier that helps the reader, or listener, select which computer program his brain will run to solve the patient's problem (e.g., chronic diarrhea, acute shortness of breath, acute chest pain, etc.).

In psychiatry, the axiom is that the chief complaint "tells it all." Although at first one does not have enough information about the patient to understand the true, deep meaning of the stated chief complaint, it is a key datum to the psychiatrist.

For the Student. Think of the *chief complaint* as the patient's *chief concern*. A "concern" is less likely to be translated into biomedical language, and its verbatim statement may presage more attention to the patient's voice, not just in the history of the present illness, but throughout the course of medical treatment (Donnelly, 1997).

For the Attending. In a study of four house officers presenting cases to senior clinicians at morning report (and unaware that they were being studied), no chief complaint was ever stated in 17% of the cases. In the remaining 83%, there was an average wait of 36 seconds (range: 5 seconds to 3 minutes 20 seconds) before the chief complaint was announced. This is simply too long a wait for "selecting a program" because unassimilable facts are meanwhile being presented with no framework upon which they could be arranged.

Dimensions of a Symptom

In order to analyze any symptom, including the leading symptom of the present illness, one must fully describe the symptom in all its dimensions. (If you have already learned a system, such as the PQRST[1] method of describing pain [DeGowin and DeGowin, 1970] or the "seven dimensions" listed in Morgan and Engel [1969], you may elect to skip this section and continue with the good habits already formed. If you have not already learned a set of dimensions, this one is offered. A list of the dimensions [whichever one you choose] is probably the only list in all of clinical examination worth memorizing. Everything else can be learned by repetition and can be kept on an index card or a notebook in the interim.)

The dimensions I use are as follows:

1. Time
2. Quantity
3. Location
4. Aggravating factors
5. Alleviating factors
6. Quality
7. Setting
8. Associated symptoms
9. Inconstant dimensions (color, clarity, consistency, etc.)

Time

Time may actually be of several dimensions, as we shall shortly see. At first glance, it might seem that the dimension of time has already been presented for the symptom of the chief complaint because the duration is a statement in this dimension. And for some symptoms, this is true (e.g., "cyanosis since birth" in cases of congenital heart disease with right-to-left shunting). But in other cases, the issue is much more complicated than a simple issue of duration.

For instance, consider this account of crescendo angina:

> At first that squeezing pain just lasted about 10 or 20 seconds. It started to go away as soon as I stopped walking up the hill, but later, around that Christmas, when that aching became more frequent, I mean I started getting attacks almost everyday by then, just stopping didn't do anything for me. I had to get the nitro under my tongue, and then I had to wait for it to work, oh maybe 2, 3 minutes, but I was still doing okay, going to work every day. Well, Sunday morning when we were getting ready for the birthday party, I noticed all of a sudden ….

Here the patient is describing the duration of the individual attack, the duration of the relief of symptoms, and the frequency of the attacks, all of which are expressed in units of time and each of

[1] PQRST is a mnemonic standing for provocative–palliative factors, quality, region, severity, and temporal characteristics.

which must also be described in the record within the chronologic dimension. If one had only the duration of the symptom, one could not make the diagnosis of crescendo angina.

With further questioning, one could add still another time measure: How long the patient could walk up that hill before the "squeezing–aching" would appear.

It will become obvious that there are many other important symptoms existing in time that we have not discussed here. To give one additional example, students are taught to ask whether there is an "aura" or warning in evaluating the complaint of syncope. But even more useful is the time dimension of the aura because patients with vasovagal syncope tend to have a long aura (about 2.5 minutes), while those with cardiac syncope usually have a very brief aura (<3 seconds) rather than none at all (Martin et al., 1983).

When the onset of the illness is vague or the description seems somewhat sparse, a useful question to ask the patient is this: "When is the last time you can remember feeling perfectly healthy?" Use exactly these words.

The purpose of this question is to get the patient talking. It is not intended to determine when the history of the present illness began, although sometimes it will do that. The idea is to increase the number of historic facts at your disposal. After you get all the facts, you will be able to determine the beginning of the present illness. In addition to sharpening up the early history of the present illness by giving the patient a chance to reflect and recall, this question often stimulates patients to talk about other symptoms that they had momentarily pushed out of consciousness or that the listener had not attended to at first.

It is important to understand that this question is not the same as, "When did you first get sick?" or even, "When is the last time you did not have (the given symptom)?" Those are not really open-ended questions. The question as stated in the first paragraph is open-ended, provided that you listen to the answer without interrupting.

A feature of timing that is pertinent to a wide range of specific symptoms is the relationship of the onset to any drugs that the patient may be taking. The probability of various side effects may be found in the *Physicians Desk Reference*. However, this author frequently relearns the dictum taught at Parkland Memorial Hospital: "Any drug can do anything." Adverse reactions may be paradoxical or difficult to distinguish from the condition being treated, as with suicidality or violent behavior associated with certain antidepressants (Kauffman, 2009). They may be rare, unanticipated from the drug's purported mechanism of action, or simply underreported, for example, irritability and aggressive behavior on cholesterol-lowering drugs (Golomb et al., 2004; Tatley and Savage, 2007). Adverse effects do not necessarily have an immediate onset. Some, such as cognitive impairment due to diazepam, occur as a long-lived drug accumulates. Allergic or idiosyncratic reactions can occur unpredictably in patients who have previously tolerated a drug very well. The *post hoc ergo proper hoc* fallacy is always a risk when attributing a finding to a drug (see Chapter 27), yet continued use of a drug for fear of the fallacy can do continued harm if the drug truly is the culprit.

Quantity

Some examples of quantity are "three tablespoons of sputum each morning," "two-pillow orthopnea," "about one-half cup of bloody emesis," or "claudication that had formerly appeared after four or five level blocks, now occurring regularly at one block."

Some symptoms, such as pain, have no international units but can still be expressed on an analog scale from 0 to 10, where 0 is the absence of the symptom and 10 is an extreme, such as "so bad you would have killed yourself."

Other symptoms cannot be described in cardinal numbers but still require a salient, concrete description. Adjectives (such as "terrible") are much less useful than the answer to the question, "What could you do in the past that you cannot do now because of (this symptom)?" The patient might respond that he can no longer walk across the room to the toilet because of shortness of breath.

Location

Although location might well have been covered in the chief complaint, if the chief complaint is the leading symptom of the present illness, the use of the patient's own words might preclude a precise description at that point. The pain in the "tummy" might be in the epigastrium, hypochondrium, periumbilical area, suprapubic area, or even the colon and rectum. A misinterpretation of the term "tummy" by the physician will, at best, delay the diagnosis. Similarly, the "hip" can be the buttock, the rectum, the actual hip joint, the iliac crest, the skin on the lateral surface of the buttock, or nodes in the inguinal or femoral areas. Sometimes it is the doctor who is imprecise; he might change the patient's "thigh," "knee," "calf," "ankle," or "instep" into the "left lower extremity," thereby homogenizing, instead of refining, these terms.

Some symptoms, such as weakness, do not always have a location. This is also important to establish and to note in the record. The differential diagnosis of weakness in the right hand is completely different from that of generalized weakness that is not focal.

For certain symptoms, particularly pain, the dimension of location also includes radiation, which is where the symptoms move (see the sections on the "Durga and pseudo-Durga syndromes").

Aggravating and Alleviating Factors

The patient should be asked about aggravating factors in an open-ended manner: "What kinds of things might make it worse?" Although aggravating factors are usually analyzed in conjunction with alleviating factors, a separate question should be used for the latter. If you ask the patient, "What kinds of things make this better or worse?" most patients will answer only the second part of the question and will never return to the alleviating factors. The physician who asks this question may then remember "no data" as the alleviating factor. (This, of course, is one form of the dreaded double question [see Chapter 2]. If you audit your tape recordings carefully, you will be amazed by how often you use double questions. Avoiding them is a learned skill.)

To illustrate the utility of the aggravating and alleviating factors, consider two patients with left-sided anterior chest pain. One patient's pain is induced by exercise and strong emotions but consistently relieved by rest and sublingual nitroglycerin; this is characteristic of angina pectoris. The other patient's pain is aggravated by sneezing, coughing, and respiration but alleviated by shallow breathing and splinting of the left side of the chest; this patient has pleurisy. Although the patient may not always have such a classic history, the physician will never learn of these diagnostic

clues, even when readily available, if he does not ask the proper questions.

Quality

The quality of the symptom is most important for the very symptoms that at first glance seem to be least susceptible to a qualitative description. For instance, Samuel Levine used to tell his students that if the patient's chest pain was glibly and clearly communicated it was probably not myocardial in origin. The difficulty that the patient experienced in describing the pain was in itself a diagnostic clue.

When a patient complains of "spells," "falling out," "risings" (or "kernels"), weakness, back pain, or fatigue, a good opening question is, "Could you tell me more about what that was like?"

Not all the information obtained in response to that question will necessarily be in the dimension of quality. In fact, some patients will proceed to describe almost everything else except the quality: where he was when the symptom occurred, the time of day, statements of other persons, opinions of other physicians, and accounts of the symptoms of other family members. Ask such patients, "Could you tell me more about what it felt like to you?" If the patient truly seems to display alexithymia (the inability to describe mood and feelings), try the question, "What might I have had that would feel most like what you are describing?"

Setting

Determination of the setting in which a symptom began is useful in direct proportion to the breadth of the interviewer's view of the word "setting." A narrow interviewer may only inquire, and episodically at that, as to the patient's position (as in syncope), time of day (as for ulcer pain), recent ingestion of alcoholic beverages (for determining the etiology of pancreatitis), and so forth. This restricted view leads to a number of problems.

Narrow inquiries into "setting" are not open-ended information-gathering devices but branch-point signs at best, or, more usually, a means of confirming diagnoses already suggested to the interviewer. The answers to "setting" questions generated in this fashion cannot be used for research purposes because they are not asked of all patients. They cannot be used for learning purposes for a related reason (i.e., their unknown specificity). They are not useful in patient care because they are *post facto* to diagnoses considered for some other reason, or are simply window dressing, as in the following example.

One morning, I was presented a 28-year-old black man who had been admitted with crushing chest pain, precordial Q waves, huge ST-segment elevations, T wave inversions, and increased levels of the cardiac enzymes. The diagnosis of myocardial infarction was evident to everyone.

Most of the history of the present illness was a recitation of the following facts:

1. The patient was not sedentary, being a basketball player.
2. He was not overweight.
3. He had never smoked.
4. He did not have diabetes mellitus; his blood sugar was normal on a recent preemployment physical.
5. The cholesterol and triglyceride levels were known to be normal.
6. There was no family history of heart disease.
7. He was not hypertensive.

When I inquired why I was being given this information, I was told that the patient had been diagnosed (correctly) as suffering from a myocardial infarction and that these were the risk factors for atherosclerotic coronary artery disease. Although the patient did not have any of these risk factors, the cardiology consultant had nonetheless suggested atherosclerosis as the etiology of the disease. Because of the narrowness of focus in contemporary medicine (engendered, in part, by such *post facto* lists), unusual diagnoses, such as coronary artery arteritis, a coronary embolus, or a congenital anomaly of the coronary circulation, were not considered. Once the patient was labeled as having atherosclerosis, despite the absence of risk factors, all investigations were stopped cold.

Open-ended setting questions will often provide important clues to a correct diagnosis that will be missed by the Procrusteans (i.e., those who insist that the patient's story must fit their preconceived notions, just as travelers had to fit the mythical innkeeper's bed). The patient might start talking about something he had not told anyone before, for example, recent recurring spells of despondency, leading to further questions and possibly to a diagnosis of anxiety or depression on a positive basis, rather than the always treacherous exclusionary one. Also, open-ended questions help the interviewer understand the patient as a person.

Another error of the Procrusteans is to insist that the setting must be the one expected on a *post facto* basis, regardless of what the patient says. If the patient has told you that his symptoms do not occur in a setting of strong emotional arousal, you should not insist that they do. I have seen this error made in more than one patient suffering with (undiagnosed) acute intermittent porphyria, whose symptoms had been attributed to "nerves" by several physicians.

A broad interpretation of setting may lead to the discovery of new diseases, as in the story of Soma Weiss' streetcar conductor (see Chapter 18). An interest in the setting is also important to the mental hygiene of the physician. If you do not have this basic curiosity about your patients and their illnesses, you will soon be practicing apple-sorter medicine. After a few years of seeing the apples only in the single dimension of size and ignoring their colors, tastes, smells, bumps, bruises, and curious travels, your medical practice will become one-dimensional, causing boredom and burnout in your life's work.

Finally, a broad understanding of the onset setting may be useful in management as well as diagnosis. The physician should be particularly sensitive to absences and partings. If the onset of the illness was in the setting of the loss of a significant other, then a similar loss of the physician (who may be quite significant to the patient) may be expected to produce perturbations both in the patient and in the patient–physician relationship. Loss can be permanent (death or abandonment), temporary (vacation or illness on the part of the physician), or anticipated (either based in reality or the fantasy of the patient).

For the Junior Student. If you do attempt to elicit the history in the manner described here, you may find yourself in conflict with some of the medical residents with whom you must work. They will want you to "get in and get out" and "just get the facts" as they perceive them. While their approach may yield certain short-term benefits, it will deprive you of the opportunity to learn certain enduring skills, which are not easily acquired later. You must decide

whether you want to learn a difficult but valuable technique from the patients assigned to you or whether you would prefer to be a donut-and-cup bearer to the tin gods of the buffed chart.

For Students of All Levels. If you want to excel at history taking, you must read about the problems that you are seeing. You will often want to return to the patient to obtain more information about certain dimensions of a symptom based on your reading.

For the Attending. The patient's culture and language are extremely important parts of the setting, both for the interviewing process and the composition of the history. Unfortunately, this is very difficult to teach to the beginning student who is going through an acculturation process himself. By the time the young physician can appreciate these issues fully, he no longer needs to be reminded of them by the written word. The only effective method of instruction is at the bedside with a live patient.

Associated Symptoms

Associated symptoms are those that appear in some regular relationship to the symptom under analysis. This dimension often increases the diagnostic significance of the symptom severalfold. For instance, while polydipsia, polyphagia, and polyuria are each individually nonspecific, when combined they are so characteristic of new-onset diabetes mellitus that they can be considered a diagnostic triad. Weight loss, fatigue, and anorexia might suggest an occult neoplasm, but weight loss, fatigue, and perspiration could be symptoms of hyperthyroidism or tuberculosis. If paroxysms of perspiration and headaches were accompanied by palpitations, one would think of pheochromocytoma, but if they were temporally associated with bed-shaking chills, one would suspect an infectious process. The associated symptoms of *dolor pectoris* (chest pain) and *angor animi* (a sense of impending doom, *vide infra*) from myocardial infarction are an example of concurrent symptoms that may occur only once. Associated symptoms of a chronic complaint may not always be exactly concurrent, but they should be more or less consistent.

In infection, bed shaking occurs during the "chill" part of the temperature curve. Unfortunately, some patients may not notice the phases of their febrile illness, and they may report bed-shaking chills concurrent with or even preceding the fever. The association of symptoms is useful, even if the sequence is imprecisely remembered.

Associated symptoms do not lend themselves to easy listing like some of the other dimensions. Inquiring about them requires some knowledge of medicine. Otherwise, who would think to ask about itching when trying to evaluate jaundice? Yet this symptom can help distinguish hepatic obstruction (in which itching due to bile salt retention can occur before the individual becomes overtly jaundiced) from hemolytic jaundice. Factors that facilitate the appearance of bile salt pruritus are hot baths and aging, dry skin. Again, who would think to ask about hot baths if he had not seen or read much medicine?

Inconstant Dimensions

Inconstant dimensions are those that do not apply to all symptoms but that are, nevertheless, very important for some, such as color, clarity, consistency, and so forth.

Color Card

Color must be described for urine, sputum, feces, skin lesions, and the skin overlying an arthralgia. Sometimes it is of great importance to know the exact color. To be sure that you and the patient are thinking of the same colors, prepare a color card consisting of patches of various colors, particularly blood red, currant jelly purple, robin's egg blue, tar black, very dark brown (almost but not quite black), cola brown, medium brown (umber or sienna), light brown, clay white, biliverdin green, bilirubin orange, lemon yellow, and several shades of gray. These can be mixed from oil paints or composed of paint store sample chips. More simply, cut the appropriate colors from magazine illustrations; paste them on a card; and, for permanence, laminate in plastic.

Clarity, Consistency, and So Forth

Body fluids may be clear, opalescent, translucent, opaque, transparent, turbid, like "gold paint," and so forth. Each of these adjectives might be of diagnostic value when applied to a pleural effusion, if one is so fortunate as to have a patient who remembered what his pleural fluid looked like the last time it was tapped.

A description of the consistency of materials may be very helpful. For example, the term *diarrhea* may mean many different things, referring either to the frequency or to the volume of bowel movements. However, a statement of consistency (i.e., whether the stool would assume the shape of its container) is clearly understandable.

Similarly, pain, which does not have the properties of color or consistency, may have the property of being "colicky," especially when it is abdominal (see Chapter 20).

Although precise descriptions are important, one must also avoid becoming dogmatic about the meaning of certain findings.

An Example

Pseudomonas was formerly known as *Bacillus pyocyaneus*. *Pyocyaneus* means bluish pus, although sometimes the pus from *Pseudomonas* infections is actually green from the fluorescein produced by the organism. However, the idea that green pus is diagnostic for *Pseudomonas* is not correct. Any pus can be green if it contains sufficient white cells and their verdoperoxidase, a copper-containing myeloperoxidase.

Abbreviated History in Trauma Patients

In trauma patients, especially those with a suspected head injury, an expedited history (and complete, if rapid, physical examination) must be obtained because the patient might lose consciousness after an initial lucid interval. In the context of an emergency in which surgery may be necessary, obtain at least the "AMPLE" history recommended by the Advanced Trauma Life Support Course of the American College of Surgeons: allergies, medications, past illnesses, last meal, and events preceding the injury.

Elaboration of Selected Symptoms

The symptoms discussed in this section might occur either in the review of systems or in the history of the present illness. The treatment is not encyclopedic but, rather, illustrative of how useful

the history can be and how detailed the history may *need* to be in order to arrive at a diagnosis. The actual inventory discussed here is quite small compared to the entire inventory of questions available to the clinician; it is even smaller compared to the short inventory of questions given in Chapter 4.

Pain

Pain is the body's signal that something is wrong. The perception of pain consists of a somatic neuronal input and a psychologic interpretation. Pain as a manifestation of various specific ailments is discussed below. Frequently, however, pain persists beyond the time when an injury is healed or the neuronal source is apparent. Chronic, intractable "pain without lesion" is increasingly recognized as a medical problem in its own right. Nearly 15% of the population in Western societies is believed to suffer daily chronic pain; in more than 10%, the pain is severe enough to interfere with daily living (Mäntyselkä et al., 2003).

Symptomatic treatment with high-dose opioids has become increasingly accepted, though fraught with hazard because of the abuse potential of these medications, the incentives inherent in a black market for a highly desired substance, and the threat to physicians from overzealous regulators and prosecutors (see Chapter 2). Physicians who undertake the management of chronic patients with controlled substances need to stay abreast of the ever-changing regulatory and legal climate. Particular care must be taken in monitoring and documenting the effect of pain and of treatment on the patient's life and ability to work or carry on activities of daily living.

Pain is unavoidably a subjective experience. Attempts to quantitate it usually rely on a visual analog scale or ranking the severity of pain on a scale such as "0" for "pain free" to "10" for "the worst pain you can imagine" or "pain so bad you would kill yourself." One clinical pain diagram is shown in Fig. 25-5. These days, students probably cannot avoid seeing the "smiley face" posters in their hospitals, provided by a manufacturer of analgesics.

Despite proclamations from the Joint Commission on Accreditation of Health Care Organizations, pain is not a "fifth vital sign." It is a *symptom* reported by the patient and not an objective measurement of a physiologic process necessary to sustain life.

One attempt to measure pain quantitatively is described below.

Sternbach Pain Thermometer

Sternbach developed a technique to improve the interviewer's understanding of both (a) the quantitative aspect of the patient's pain and (b) the patient's reporting of the pain, which he called the "pain thermometer" (Sternbach, 1974).

A Method

The patient is first asked to quantitate the intensity (not the character) of his pain on a scale from 0 to 10, wherein 0 is absolutely no pain and 10 is a pain so terrible that it would cause one to commit suicide.

A blood pressure cuff is then placed in the usual position and inflated to far above the systolic so as to produce ischemic pain. At the same time, a stopwatch is started. The patient is instructed to report the time at which the ischemic pain is of the same intensity as the pain reported in the history.

When the patient reports this experience, record the number of elapsed seconds but do not deflate the cuff. This will be the numerator. The end point or denominator of the pain thermometer ratio is reached when the patient either rips off the cuff or demands that it be removed.

Interpretation

For a hypothetical situation in which a patient reported his naturally occurring pain to be a 5 on a scale from 0 to 10, there are three possible results with the pain tourniquet test.

1. The patient hypothetically experienced the same intensity of pain after 50 seconds of tourniquet pressure and ripped off the cuff at 100 seconds, yielding a fraction exactly equal to that predicted from his subjective estimation of 5 out of 10. We would say that this patient is an excellent "reporter" of pain. That is, he is precise and accurate.
2. Overreporting would be suggested if the tourniquet test yielded, say, a fraction of 20 seconds over 200 seconds. This result would have been the equivalent of a 1 out of 10 on the patient's subjective rating scale. This would suggest that the patient is sensitive to naturally occurring pain and tends to overrate or overreport it or that the patient could have a superior tolerance for experimental pain, superior even to his own estimation!
3. The patient might report the tourniquet pain to equal the naturally occurring pain at 90 seconds and rip the tourniquet off at 100 seconds, yielding a ratio of 0.9, rather than the expected 0.5. This patient could either be underreporting the naturally occurring pain or be demonstrating a low tolerance for the experimental pain.

Note that the pain thermometer, in itself, tells you nothing about the etiology of the pain, although occasionally it may be helpful in suggesting a more aggressive diagnostic effort. A malingerer might be expected to have widely varying tourniquet ratio scores from trial to trial or response 2, described above. One woman with a subjective rating of 5 out of 10 was thought to be a malingerer, especially after a completely negative radiologic evaluation of her epigastric pain. She still had not reported even the numerator for the pain thermometer after 9 minutes of ischemia. This was so startling that she was subjected to endoscopy, revealing a large gastric ulcer that had been missed by the contrast studies.

Angina and Other Chest Discomfort Syndromes

If you want to experience severe anginal pain yourself, place a blood pressure cuff on your upper arm, pump it up to 300 mm Hg, and occlude the tubing with a towel clip so there is no slippage. After 5 minutes, work your fist. The feeling in your forearm is the same as the feeling in the chest in severe angina.

Angina is a peculiar disorder in that its timing in some patients is absolutely predictable, coming on at certain times of day or with taking a certain number of steps (Swartout, 1987).

Angina pectoris may be associated with *angor animi*, which literally means anguish of the soul. Because modern man has shed his soul, we now call this a sense of impending doom, which may often accompany myocardial infarction, dissecting aneurysm, or massive pulmonary embolism. The visceral sensation that accompanies the catecholamine discharge can be confused with nausea.

In a description based on personal experience of angina pectoris and other chest pains (Swartout, 1987), it is noted that the substernal pressure caused by severe asthma and the pain of acute cholecystitis, which may be just as severe as angina, are not associated with *angor animi*. The pain of pericarditis is boring and continuous, but it is also positional.

A study of the utility of patient gestures in determining the etiology of chest discomfort showed that the frequently described Levine sign (clenched fist over the sternum) has a sensitivity of only 9% for myocardial infarction, with a specificity of 84%, a positive predictive value of 50%, and a negative predictive value of 31%. A flat hand placed over the sternum had a higher sensitivity (38%), with a specificity of 67%, positive predictive value 65%, and negative predictive value 49%. A larger area of chest discomfort was suggestive of myocardial ischemia (Marcus et al., 2007). An earlier British study, using patient interviews from the emergency department rather than after admission, showed that a clenched fist or flat hand over the sternum, or both flat hands drawn from the center of the chest outward, had a sensitivity of 80%, a specificity of 49%, a positive predictive value of 77%, and a negative predictive value of 53% (Edmondstone, 1995).

Various features of the history in patients with chest pain, and their value in calculating the probability of coronary artery disease, have been extensively studied. Pain brought on by exertion, a need to stop all activities when pain occurs, and pain relief within 3 minutes of taking nitroglycerin are strongly correlated with the presence of coronary artery disease. Substernal location, radiation to the left arm, and a "pressure" sensation are positively correlated, whereas pain described as "sharp" or pain brought on by cough, deep breathing, or moving the arms or torso is negatively correlated with coronary artery disease. Numeric weights can be assigned to each feature, and a logistic chest pain score can be calculated. Students are cautioned that such methods give a probability, not a diagnosis. Before placing too much reliance on a numeric score, students must remember the caveat that the predictive value of such scores, like that of isolated findings, depends on the prevalence of the disease in the population from which the patient comes (Sox et al., 1990).

An interesting by-product from studies of the chest pain rule is the finding that data obtained by physician interviews were better at predicting disease than data from self-administered questionnaires. The researchers concluded that physicians may have a higher sensitivity to subtle clues in the patient's history that suggest severe disease (Hickam et al., 1985). An interview by a skilled human clinician is more than the sum of the boxes on a checklist.

Note that absence of chest pain does not rule out an impending myocardial infarction, especially in women. Only about 30% of women had chest discomfort, a hallmark symptom in men, before their acute infarction. The most frequent prodromal symptoms in the month before the event were fatigue (71%), sleep disturbance (48%), and shortness of breath (42%). Even at the time of the infarction, acute chest pain was absent in 43% of women (McSweeney et al., 2003).

An Illustrative Case

A patient with retrosternal pain, and what was reported as nausea, was sent to the gastroenterology unit for evaluation.

Patient: "… and with the pain I had this feeling in my stomach …"

Attending: "Nausea?" (The word the resident had used.)

Patient: "Yeah, I guess it was nausea. You could call it that. The pain was terrible."

Attending: "Did you want to throw up, vomit, with the pain and nausea?

Patient: "No, not at all. I just wanted to be still."

Attending: "You had nausea, but you didn't want to throw up."

Patient: "No. If I was sick like that I would ordinarily want to vomit to feel better, but this wasn't the same thing."

Attending: (Motions "tell me more" with his hand.)

Patient: "… This was a bad feeling all over and also in the pit of my stomach. When that pain came on and stayed and would not go away, I got this feeling that the end of the world was coming … I didn't think I was going to make it …"

Attending: "And the nausea? The feeling? … Was it really nausea? …"

Patient: "No, it was a bad feeling, it was worse than what I call nausea. It was this clutching feeling you get when you are very excited. Like in sports, when you are in sporting events, and you are about to go out there, … go on the playing field. … you get before a football game. I used to play football. Well that was the feeling I got in my stomach when this pain came on. I thought, my God, this is it. I was terrified. I thought maybe if I did nothing it would go away. I thought this is it, and that is when I got the stomach, the nausea feeling you [sic] call it. But I didn't want to vomit, I didn't want to do nothing, I just wanted to live. That was the worst part of the pain, knowing that there was something about that pain that could … you know, it could do you in."

This patient was subsequently found to have had a myocardial infarction and was transferred from the gastroenterology unit to the coronary care unit.

Chills and Night Sweats

Patients who report chills should be asked whether the bed actually shook or moved on the floor. A true shaking chill also tends to last a definite period, on the order of 30 minutes. Shaking chills, as opposed to a sensation of chilliness, have diagnostic implications and are always high on the list of findings that must be explained by the primary diagnosis. They also imply that the fever was high, even though the patient may not have measured it.

Night sweats should be described in quantitative, practical terms. For example, "Were the sweats so bad that you had to change your pajamas?" Or, "Did you have to change the pillowcase to get back to sleep?" Or, "Did your wife change the sheets?" Note that patients who sleep in warm weather in non–air-conditioned rooms do not soak the sheets as highly febrile patients do. They simply cast the sheets off and roll away from any dampness, and of course, they are never awakened by a chill.

The old teaching that viral diseases did not cause bed-shaking chills is probably incorrect; patients with dengue fever, for instance, shake the bed.

Itching

Itching is usually a manifestation of cutaneous disease but may also result from a systemic condition (Bernhard, 1987). A drug history is most important. Phenothiazines, tolbutamide, erythromycin, anabolic hormones, estrogen, progesterone, and testosterone may cause itching by inducing cholestasis, narcotics through histamine release, and aspirin through prostaglandin effects. Any drug may

cause pruritus through an idiosyncratic effect, even if the patient has been taking it for years.

Inquire about exposures to fiberglass, dusts, and chemicals. In addition, in many patients with unexplained pruritus, a veterinary examination may identify exposure to ectoparasites from pets.

Itching severe enough to waken the patient at night should arouse suspicion of scabies or dermatitis herpetiformis. If these conditions are ruled out in a patient with severe itching, consider a systemic cause.

Systemic diseases associated with itching include renal failure (due to secondary hyperparathyroidism); endocrine conditions (thyroid dysfunction, diabetes mellitus, and carcinoid syndrome); hematologic conditions (such as hemochromatosis and polycythemia vera); and hepatobiliary disease, especially with biliary obstruction (as in primary biliary cirrhosis or carcinoma causing extrahepatic obstruction—note that itching due to the retention of bile salts may precede the appearance of jaundice). Itching produced by bathing (aquagenic pruritus) may be a symptom of polycythemia vera, Hodgkin disease, mastocytosis, or aging (Phillips, 1992). Nearly 30% of patients with Hodgkin disease have severe burning pruritus (Bernhard, 1987). Other malignant causes include visceral cancers, mycosis fungoides, multiple myeloma, and central nervous system tumors.

Hemoptysis versus Hematemesis

Hemoptysis literally means "to spit up blood," and hematemesis means "to vomit up blood." As actually used, hemoptysis refers to the experience of coughing up blood, and by extension, it refers to any blood produced through the mouth but originating in the pulmonary system.

The four main causes of hemoptysis used to be bronchogenic carcinoma, bronchiectasis, rheumatic mitral valve disease (especially mitral stenosis), and tuberculosis. While this remains a useful mnemonic for the previously asymptomatic patient who presents with a sudden hemoptysis, it is less accurate today. The prevalence of bronchiectasis, tuberculosis, and rheumatic heart disease has decreased substantially. In a study conducted in Jerusalem between 1990 and 1995, the most common causes of hemoptysis were bronchiectasis (20%), lung cancer (19%), bronchitis (18%), and pneumonia (16%) (Hirshberg et al., 1997). In a study in Kansas City, Missouri, the most common cause was bronchitis (26%) (Reisz et al., 1997).

A serious but treatable cause that may be overlooked in both children and adults is an inhaled foreign body. This may occur in persons who have no risk factors such as memory loss, seizures, or alcoholism. The hemoptysis may be massive in the case of inhaled vegetable matter, which may induce florid bronchiectasis and vascular changes (Dore et al., 1997). The patient is likely to have a chronic cough and may have a history of sudden onset of cough followed by wheezing or dyspnea (Al-Majed et al., 1997). This condition illustrates that to make a diagnosis, preferably by means other than surgical pathology, one must think of it.

In the areas of the world where tuberculosis is still a problem, more specific etiologies of hemoptysis need to be considered, including Rasmussen aneurysm or secondary aspergillosis. (Taking one item out of a differential diagnosis and performing a more sophisticated differential of that condition, as was just done, is called "going up to the next level of complexity.")

In about 20% of cases, no cause for hemoptysis is found despite extensive investigation (and a lengthy list of uncommon possibilities). The risk of recurrence is low (Dore et al., 1997). Knowledge of facts like this will help a physician reassure a patient who has experienced a frightening symptom, but should not serve as a pretext to forgo a thorough investigation, particularly if the symptom is recurrent.

Of course, hematemesis is caused by an entirely different set of diagnostic possibilities. It usually implies a source of blood proximal to the ligament of Treitz and therefore includes gastric ulcer, gastric carcinoma, Osler–Weber–Rendu syndrome, esophageal varices, and so forth. Conceivably, it could be caused by epistaxis, assuming that the patient swallowed the blood and vomited it later.

The physician is responsible for making the distinction if the patient reports, "I spit up blood." To qualify it as hematemesis, the patient should have actually gagged and regurgitated the bolus of blood. On the other hand, patients with hemoptysis usually can recall a clear episode of coughing. Often, they can point to the side of the thorax from which the blood came. Unfortunately, even excellent interviewers may not be able to make the distinction 100% of the time. However, one becomes more skilled by interviewing many patients with this complaint prior to knowing the anatomically determined source of the bleeding.

Chronic Cough

Chronic cough is one of the top five reasons for consulting family physicians. The diagnosis may be missed for years, especially if the physician focuses solely on the chest. There are receptors that can provoke a reflex cough in the ear, the esophagus, and the pericardium, as well as the tracheobronchial tree (Bellanti et al., 2000).

Important dimensions include exacerbating and relieving factors. Cough due to asthma may be provoked by exposures or exercise. Psychogenic cough, which may be quite severe, is relieved by sleep or distraction. Ask about response to past therapies. Relief from steroids suggests an inflammatory condition, from antibiotics, an infection, most often sinusitis. Proton pump inhibitors may relieve cough resulting from gastroesophageal reflux, whether due to microaspiration or receptors in the esophagus.

Always take a drug history: Up to 20% of patients taking ACE (angiotensin-converting enzyme) inhibitors have a cough. Important associated symptoms or signs include sinus congestion and postnasal drip, cardiac arrhythmias (which can cause a cough relieved by correcting the arrhythmia), and symptoms related to acid reflux. The presence or absence of purulent sputum is usually of little diagnostic help (Stulbarg, 2003).

An unusual cause of cough, generally associated with headache, toothache, fever, or upper limb ischemic symptoms, is temporal arteritis (Hellmann, 2002). A high index of suspicion in patients older than about 50 may lead to early diagnosis and prevention of blindness or other devastating complications.

Think of risk factors for possible infectious etiologies. Ask about fevers, night sweats, past skin tests, and constitutional symptoms (weight loss, anorexia, fatigue, etc.). A recent viral illness may cause a postviral sensitivity with cough that lasts for months. In patients who might have been exposed, perhaps without being aware of it, pertussis is surprisingly common, even in adults who have been vaccinated. Pertussis is diagnosed in about 20% of patients who present to an

ER with a cough lasting from 3 to 12 weeks. Consider *Mycobacterium avium* complex (MAC) in patients who may be immunosuppressed.

Although physicians may gain some clues from listening to the cough, the patient's description is generally not diagnostically helpful (Stulbarg, 2003).

A history of a negative chest radiograph is not helpful, as standard films are quite insensitive. Computerized tomography may reveal an endobronchial tumor, tuberculosis, interstitial disease, bronchiectasis, or the nodular infiltrate of MAC in a patient with a normal or nearly normal radiograph.

The three most common causes of cough in patients with a normal chest X-ray who are nonsmokers and not taking an ACE inhibitor are gastroesophageal reflux disease, postnasal drip syndrome, and asthma, with the majority of patients having more than one cause (Mello et al., 1996).

In children, consider congenital malformations, cystic fibrosis, and aspiration of foreign bodies. In adolescents, repetitive cough may be the presenting symptom of Tourette syndrome (Hogan and Wilson, 1999).

One 30-year cough was instantly cured by removing a hair touching the patient's eardrum (Stulbarg, 2003).

Dysphagia

The diagnosis of difficulty swallowing can generally be made on the basis of the history. Dr Stuart Danovitch of Washington, DC, writes that progressive, short-duration dysphagia, chiefly for solids and ultimately for liquids, is exceedingly characteristic of cancer. Weight loss is generally associated. Progressive dysphagia for solids over years characterizes peptic stricture and would be supported by a history of heartburn and antacid ingestion. Nonprogressive, intermittent dysphagia for solids, especially occurring early in a meal, is typical for a lower esophageal (Schatzki) ring. Slowly progressive dysphagia, over a period of years, for both liquids and solids suggests achalasia. Intermittent, minimally progressive dysphagia and odynophagia characterize esophageal spasm, particularly when accompanied by chest pain. Reviewing previous medical records helps obtain a good picture of the longitudinal progression of the disease (S. Danovitch, *personal communication*, 2004).

Abdominal Pain

The differential diagnosis of abdominal pain in various locations is discussed in Chapter 20. A general observation is that lower abdominal disorders may present with upper and midabdominal complaints, whereas upper abdominal disease such as cholecystitis or pancreatitis are far less likely to present with lower abdominal complaints (S. Danovitch, *personal communication*, 2004).

Is the Pain Colicky?

To determine whether an abdominal pain is colicky, I prefer to get a description of temporal waves of pain, whose peak comes and goes with some regularity, like labor pains. Do not use the nonspecific descriptor "crampy." To some patients, especially men, a cramp is a continuous muscle pain that does not have waves of intensity.

Colicky Pain Originates from a Hollow Viscus

If the pain is colicky, one knows that it is not coming from the liver, spleen, or kidney but could be coming from the bowel or the ureters. (Ureteral pain is easy to recognize because of its location in the flank. The distal ureters refer pain to the testicles.) However, a steady pain could also come from a hollow viscus, such as the gallbladder. Pain caused by pancreatitis (an inflammation of a solid organ) might be colicky because of associated small bowel ileus or a stone in the pancreatic ducts (although pain in the latter case, like a common bile duct obstruction, could also be steady). The term *biliary colic* is a misnomer; biliary obstruction produces pain of a steady, nonparoxysmal nature (see Cope's classic work [Silen, 1979], reviewed in Chapter 20).

Periodicity of Abdominal Pain

If the pain is colicky, one should try to determine its periodicity. Women patients who have experienced childbirth are particularly good informants. The periodicity of the colic in pain from the upper ileum is stated to be 3 to 5 minutes, as opposed to 6 to 10 minutes for the lower ileum (Silen, 1979).

This contention seems contrary to current gastrointestinal physiology, which leads one to expect pacemakers lower in the gut to have shorter periods. Cope (Silen, 1979) does not offer any data but cites a reference that states: "There is support for the thesis that the waves of propulsive activity in the intestine come with somewhat greater frequency high in the ileum than lower down. In practice, an obstruction high in the ileum appears to be characterized oftener by a period of 3 to 5 minutes between peaks of crampy pain, and obstruction in the terminal ileum by intervals between the pains that are as much as twice as long (Dennis, 1954)."

Sometimes the periodicity of abdominal pain exists in a much longer time framework than we are used to thinking about when we describe the periodicity of colic. Abdominal pain due to allergic eosinophilic gastrointestinal disease has a periodicity of days; pain due to lead poisoning, a periodicity of days to weeks; pain due to porphyria, a periodicity of weeks; and pain due to familial Mediterranean fever, a periodicity of weeks to months.

Biliary pain, unlike renal colic, has a circadian periodicity, with the majority of attacks occurring at night; the incidence peaks around midnight. The majority of patients experience either all or more than half of the episodes of pain at or about a particular clock time, which is characteristic for the individual. The pain is not usually related to meals (Rigas et al., 1990).

Aggravating and Relieving Factors

A relationship between fluctuations in pain and gastrointestinal activity suggests a link to a hollow viscus and may point to a specific etiology. Relief by vomiting, for example, suggests a pyloric or proximal small bowel lesion. The specific nature of food that relieves or exacerbates the pain, however, is of dubious value, popular belief notwithstanding (Pasricha, 2003).

The pain of retroperitoneal processes, such as pancreatitis, tends to be relieved by maneuvers that increase the volume of this space, such as sitting up and leaning forward.

Visceral processes induce restlessness, but when parietal and somatic structures become involved, aggravation by motion, straining, or coughing is characteristic (Pasricha, 2003).

Associated Symptoms

Visceral pain tends to induce autonomic phenomena, such as changes in blood pressure and heart rate, pallor, sweating, vomiting,

and diarrhea. Most inflammatory conditions in visceral organs are associated with systemic reactions such as anorexia, malaise, or fever (Pasricha, 2003).

Epigastric Pain

If the patient is over 50 years of age, with his first attack of epigastric pain, and is also experiencing weight loss not clearly related to significant vomiting, one should suspect gastric carcinoma.

On the other hand, peptic ulcer, especially of the duodenum, is more likely to be associated with night pain, relief from food or antacids, a family history of ulcer disease, and a gesture of pointing to the epigastrium. Peptic ulcer is confusing because it may be associated with irregular bowels, even diarrhea. Because the diarrhea is due to the cathartic action of blood, the stools will often be described as black, shiny, and sticky, like tar (*vide infra*, see later in this chapter).

Irritable Bowel Syndrome

Patients with irritable bowel syndrome will sometimes have upper abdominal pain, but it will not have the characteristics described in the preceding paragraph. The diarrhea will be normal in color and not sticky. Formal criteria for the irritable bowel syndrome have been proposed (Chaudhary and Truelove, 1962; Manning et al., 1978). The Rome Diagnostic Criteria for Irritable Bowel Syndrome are listed in Table 3.1 (AGA, 1997). Diagnosis depends on identifying positive symptoms consistent with the condition and excluding other conditions with a similar presentation.

Many normal persons meet the criteria for this diagnosis although they have never sought medical help. Thus, it seems that part of the syndrome is help-seeking behavior. Patients should be asked, "What seems to be going on in your life at times when you're having more pain or more frequent bowel movements?" Psychologic factors do not make the diagnosis but do modify the experience of the illness and its outcome.

Before attributing distressing postprandial symptoms to psychogenic factors, consider the possibility that the patient has a food allergy or intolerance or impaired digestion secondary to lack of gastric acid. Take a careful dietary history and consider having the patient keep a food diary for correlation with symptoms.

It has been shown that patients with irritable bowel syndrome experience pain at distention pressures that produce, at best, normal internal sensations in normal volunteers. One theory holds that patients experienced a transient initiating event that left hyperexcitability in its wake (Pasricha, 2003).

Dermographism (see Chapter 7) is seen in some patients with diarrhea-predominant irritable colon. One may speculate about labile mast cells in the gut as well as the skin (S.H. Danovitch, *personal communication*, 2004).

TABLE **3.1** *Rome diagnostic criteria for irritable bowel syndrome*

At least 3 months of continuous or recurrent symptoms of the following:
Abdominal pain or discomfort
Relieved with defecation, associated with a change in frequency of stool, or associated with a change in consistency of stool
Two or more of the following, at least on one fourth of occasions or days:
Altered stool frequency (for research purposes altered may be defined as more than three bowel movements each day or less than three bowel movements each week), or altered stool form (lumpy/hard or loose/watery stool), or altered stool passage (straining, urgency, or feeling of incomplete evacuation), or passage of mucus, or bloating or feeling of abdominal distention

Abdominal Pain Associated with Syncope

The painful abdominal conditions most likely to cause fainting are perforation of a peptic ulcer, acute pancreatitis, ruptured aortic aneurysm, and ruptured ectopic pregnancy (Silen, 1979).

Pain Associated with Vomiting

When the leading symptoms are vomiting and pain, one should determine which came first. If the pain preceded the vomiting, one should think of diseases below the ligament of Treitz. An exception is a perforated gastric or duodenal ulcer in which the pain and vomiting may occur close together; Cope points out that the vomiting in perforated ulcer actually results from acid stimulation of the peritoneal surface. Viral gastroenteritis rarely causes this sequence of pain followed by vomiting but may cause vomiting followed by pain.

Migratory Pains

The Durga Syndrome

Durga is a Hindu goddess sometimes depicted with six or eight arms. Some patients whose pain travels in anatomically unlikely pathways may remind the student of the goddess Durga, in that more than two arms seem to be required to point out the various routes of the pain.

There are actually two such syndromes. In the first, the pain actually moves along the path described. But in the second, the pain just appears first at one place (say, the right knee) and then in a second (possibly the left elbow), without actually being experienced along the pathway that the patient infers. (Because the pain is qualitatively the same in both locations, the patient tends to assume that it must be the same pain, traveling along the shortest distance between the two points. We use the same concept in referring to the migratory polyarthritis of rheumatic fever. The arthritis does not truly migrate across intervening tissues from one joint to another.)

One can distinguish between the two forms of the Durga syndrome by asking the patient to describe the migratory pain at a midpoint along its itinerary. Patients with the second type of Durga syndrome will become puzzled and will say that they do not actually feel the pain at this or that way station, possibly infuriating the interviewer who is not familiar with this phenomenon. In this situation, one does the differential diagnosis for pain in the right knee and the left elbow, not pain moving from the right knee up the front of the right thigh, across the abdomen, and so forth.

The Pseudo-Durga Syndrome: Radiating Pain

There are certain diseases in which the pain truly does move along a seemingly bizarre path or may seem to jump from one point to another.

We have already alluded to the pain of ureteral colic, which can begin in the patient's "back" (the costovertebral angle), move around to the flank (which may be called anything from "my hip" to "my belly"), and then down into the testicles ("my privates"). Sometimes the pain ends in the groin ("in between my legs") or the medial part of the thigh (variously identified as the hip or the "leg," which means the calf to some doctors). Without taking the time to be sure of the precise topologic path, a doctor trying to identify the pain syndrome from the words used above could easily become confused.

Gallbladder pain on occasion can begin in the right upper quadrant, but instead of radiating straight through to the back, it may migrate to the right side of the abdomen, then to the left upper quadrant, and then back to the right upper quadrant. The patient might draw a circle on his ventral surface as he describes the pain. Because he looks calm, not having the pain at the moment that he is being examined, some physicians become quite frustrated by his story.

Upper quadrant pain can irritate the diaphragm and be referred to the neck or shoulder. This pattern of migration can also be a snare to the unwary.

Weight Loss

A statement about the appetite should always be included in the history of weight loss. In most cases, weight loss is accompanied by anorexia, as in depression and most cases of carcinoma, tuberculosis, and so forth.

However, if the weight loss is due to metabolic causes (such as hyperthyroidism, diabetes mellitus, or pheochromocytoma) or in some cases of collagen vascular disease, there may be no anorexia at all, and some patients with anorexia nervosa may actually have bulimia. (They eat voraciously but then induce vomiting.) Patients with malabsorption may also exhibit considerable weight loss with no decrease in appetite or even with an increase in caloric intake. Thus, weight loss without anorexia requires an additional statement about the presence or absence of diarrhea. Another cause of weight loss without anorexia (or even with voracious eating) can be Parkinson disease, especially of the postencephalitic variety. This finding was first noted by Parkinson himself (Sacks, 1973).

Weight loss can result from three general mechanisms: poor intake (or vomiting), poor digestion or absorption, or increased caloric dissipation. Try to determine which mechanism or mechanisms are involved. In pancreatic cancer, all three may contribute (S.H. Danovitch, *personal communication*, 2004).

A Caveat

Be careful to question the patient about appetite at the *beginning* of the illness. Many patients who originally had no anorexia will lose their taste for food in the course of becoming malnourished. This might be caused by a supervening zinc deficiency.

The Belt Sign

The belt sign is very useful in situations in which the patient's weight is thought to be changing. Examine the patient's belt. New holes punched, or a change in the hole that is used, may indicate decreasing or increasing girth. As a rule, the grooves near the most recently used holes tend to be sharper. The duration of use of any given hole can be estimated by the surface abrasion and width of its groove.

This principle can be extended in a number of ways. For instance, with goiter, collar size may change. In acromegaly, the glove, hat, and shoe size may change. The diagnosis of Cushing syndrome, acromegaly, hypothyroidism, and a number of other entities may be easily made by inspecting photographs of patients taken over a period of years, in their family albums.

These methods lie in the borderland between the history and the physical examination.

Vomiting

The time of onset of the vomiting and associated symptoms is very important in the differential diagnosis. Dr Lee Hershenson of Pittsburgh used to visualize the entire gut as a tube with a craniocaudal gradient. Diseases that interrupted the gradient at the rear could cause some diarrhea, eventually constipation, and finally nausea and vomiting. Diseases affecting the upper end of the gradient would cause nausea and vomiting early in the course of the disease. They would not cause early constipation (defined as the retention of feces), though a decreased amount of feces might eventually result from poor intake. Early diarrhea would not ordinarily be expected and thus would suggest the cathartic action of blood or the large volume of acid secreted in Zollinger–Ellison syndrome.

The appearance of the vomitus should be carefully described. In order to be considered "coffee-grounds emesis," the vomitus must meet three criteria: a dark brown color, a texture that resembles coffee grounds (due to blood poured into acid), and a shiny appearance (like the outside of a roasted coffee bean) due to the lipids in the red cell membrane. This permits the confident diagnosis of bleeding proximal to the ligament of Treitz.

One morning a resident announced at morning report that a patient had been admitted with a history of coffee-grounds bowel movements. This was an unprecedented occurrence. Outdated banked blood instilled through a nasogastric tube into the stomachs of healthy volunteers caused brown stools or black and tarry stools, or even (if the infusion rate was very fast) bright red blood in the stools, but no coffee-grounds stools. One suggestion was that a direct passage, a gastrocolic fistula, might permit coffee grounds to get from the stomach to the stool without the usual transformations along the way. But it was pointed out that the direction of flow in a gastrocolic fistula was from the colon to the stomach, not vice versa. Later, it developed that the patient's wife and the resident had both believed that "coffee grounds" simply meant brown. This illustrates the importance of a precise history.

Melena

> *The vomiting of blood of any kind is bad; its passage as excrement is not a good sign, nor is the passage of black stools.*
>
> —Hippocrates, *Aphorisms* 4:25

Melena is derived from the Greek word meaning black. A black stool can result from blood originating below the ligament of

Treitz (although more commonly the blood from such a location is maroon) if the blood has resided in the colon with fecal bacteria for a sufficient time. Thus, the expectation that melena means upper gastrointestinal blood loss is a statistical likelihood but not a completely reliable logical branch point. A black stool may also suggest the patient's use of charcoal, bismuth, black cherries, blueberries, or even licorice ice cream.

Two further descriptors signal that the blood did originate above the ligament of Treitz: The sticky consistency of tar and a glistening quality like tar or roofing pitch. These characteristics have not been reported in stools following a bleed into the colon.

Only 50 to 80 cc of blood is required to produce a tarry stool (Daniel and Egan, 1939). With larger amounts of blood (1,000 to 2,000 cc administered through a nasogastric tube), the tarry character may persist as long as 5 to 8 days (Schiff et al., 1942), especially if the patient receives an agent such as atropine or codeine, which slows intestinal motility.

Other Characteristics of the Stool

Pencil Stools

It was formerly taught that stools the diameter of a pencil indicated the presence of rectal carcinoma. In fact, most patients who have an episode of such stools have proctitis or other irritation of the distal sigmoid and rectum. While the irritation might be caused by a rectal carcinoma on some occasions, it most often is not. Luminal narrowing due to diverticular disease is more likely to be the explanation for narrow-caliber stool.

Stool in Malabsorption

The stools in malabsorption are characteristically described as unusually greasy, floating, and malodorous. The patient might say, "Yes, around November it got oily looking and would stick to the sides of the bowl." Or he might have noticed that his stools have become more difficult to flush because of their tendency to float. Some patients with small bowel disease but normal pancreatic function can hydrolyze much of the triglyceride into glycerol and fatty acid, and their stools may not appear extremely greasy.

Unfortunately, some patients do not observe their stools and so cannot state whether the appearance is greasy (due to undigested triglycerides) or floating (because of the high gas content). The first question you must ask is, "Do you usually look at your stools in the toilet bowl?" Do not ask, "Do you know what your stool looks like?" because many patients may examine the stool on the toilet paper but do not look at it in the bowl, so they cannot see whether it floats. Also, ask whether fat droplets can be seen floating in the water or adhering to the sides of the bowl. Dr Danovitch finds this observation to favor pancreatic rather than small bowel disease.

If the patient does not observe his stool, the question about its odor is particularly important. But if you simply ask, "Is your stool foul smelling?" he will usually reply in the affirmative. A better question is, "Have you noticed any change in the odor of your stools?" If the patient replies, "Yes. I now have to leave the bathroom window open even when it is snowing, just to get that smell out of the house," you can reliably infer that the stools are especially malodorous.

Impotence or Erectile Dysfunction

Potency is the ability to develop and maintain an erection satisfactory for penetration and sufficient stimulation of the vagina. The impotent patient should be asked whether he wishes an evaluation. If he does not, he should be asked, "Why not?" If he does, he should be asked the questions suggested below.

The patient will probably prefer to have his problem called erectile dysfunction "ED," a term that one suspects is the result of focus-group research by Internet and television advertisers of sildenafil (Viagra). This makes the problem easier to discuss and perhaps frames it as a common, manageable symptom rather than a threat to one's very manhood.

First, one must distinguish a decreased desire (decreased libido) from impotence (inability to perform, accompanied by adequate desire, at least in the early stages).

The differential diagnosis of decreased libido includes a wide variety of chronic debilitating diseases as well as psychologic conditions such as affective disorders (depressed type), adjustment reactions, and neuroses. Endocrine conditions and certain drugs can affect the libido. But peripheral neuropathy and vascular diseases should not do so initially. Some patients who repeatedly experience impotence develop a secondary decrease in attempted intercourse, not because of a primary decrease in libido per se, but rather because of the embarrassment and shame associated with the impotence. These emotional motivators can make even the thought of attempting intercourse seem noxious. These feelings can be dissected out with a few questions by a sensitive interviewer.

Impotence, on the other hand, basically involves the differential diagnosis shown in Table 3.2.

TABLE **3.2** *Causes of impotence*

Condition	Percentage of cases[a]
Endocrine[b,c]	6–44
Hypogonadism	6–39
Hyperprolactinemia	2–8
Thyroid disorder	3–4
Diabetes mellitus[d]	20
Neurologic[b]	2–7
Psychogenic[b]	14–60
Vascular[e]	1–37

[a]From Morley JE. Impotence. *Am J Med.* 1986;80:897–905, with permission.
[b]Includes drug-induced cases (Table 3.3).
[c]Includes zinc deficiency.
[d]Combined vascular and neurologic.
[e]In addition to arterial insufficiency and "steal" syndromes, vascular causes include a corporeal venous shunt (Nelson, 1987) and the combined neural and vascular problem that may be induced by compression of the blood supply to the penis and the pudendal nerves by bicycle seats (Solomon, 1987).

Associated symptoms are particularly important in assessing this problem. One should ask at least about temperature intolerance as a clue to a thyroid disorder, if one has not already done so in the review of systems. A neurologic condition will generally be associated with other neurologic symptoms as well. The sense of smell may be lost in Kallmann hypogonadotrophic hypogonadism as well as in zinc deficiency.

In up to 25% of cases, drugs cause or contribute to ED (Thomas et al., 2003). Drugs frequently associated with impotence are listed in Table 3.3. This side effect is a common reason for stopping medications, often without telling the doctor why.

TABLE **3.3** *Drugs frequently associated with impotence*

Diuretics (including thiazides, spironolactone)
Antihypertensive medications
Methyldopa
Clonidine
Reserpine
β-blockers (e.g., propranolol, atenolol, and timolol eye drops)
α-blockers (e.g., prazosin, doxazosin)
Combined α/β-blockers (e.g., labetolol)
Calcium channel blockers (e.g., nifedipine, and verapamil)
ACE inhibitors (e.g., enalapril, lisinopril) (less likely than other antihypertensives)
Anorectics
Antidepressants
Selective serotonin reuptake inhibitors (e.g., fluoxetine)
Tricyclic antidepressants (e.g., amitryptiline)
MAOI
Other psychoactive drugs (e.g., phenothiazines, haloperidol, fluphenazine, risperidone, anxiolytics, cocaine, opiates, marijuana, alcohol, and lithium)
Antiepileptic drugs (e.g., phenytoin, carbamazepine, phenobarbital, and primidone)
Anticholinergic agents (including tricyclic antidepressants, propantheline)
Antifungal agents (ketoconazole)
Proestrogens and antiandrogens (e.g., cimetidine, and clofibrate)
Cancer chemotherapy agents
Cholesterol-lowering agents (fibrates > statin drugs)
Opioid analgesics
Proton pump inhibitors (?)
Other commonly prescribed drugs (e.g., acetazolamide, digoxin, disulfiram, indomethacin, metoclopramide, metronidazole, and prochlorperazine)
Tobacco smoking

ACE, angiotensin-converting enzyme; MAOI, monoamine oxidase inhibitors. From *Med Lett Drugs Ther.* Drugs that cause sexual dysfunction, 1987;29:65–70; Brock GB, Lue TF. Drug-induced male sexual dysfunction: An update. *Drug Safety.* 1993;8:414–426; Buffum J. Prescription drugs and sexual function. *Psychiatr Med.* 1992;10:181–198; Gitlin MJ. Psychotropic medications and their effects on sexual function: Diagnosis, biology, and treatment approaches. *J Clin Psychiatry.* 1994;55:406–413; Morley JE. Impotence. *Am J Med.* 1986;80:897–905; and Nelson RP. Male sexual dysfunction: Evaluation and treatment. *South Med J.* 1987;80:69–74, with permission.

Although ED has not been reported as an adverse effect in the large controlled trials of statin drugs (hydroxymethylglutaryl-coenzyme A reductase inhibitors), it was not specifically asked about. The results of online searches and reports to regulatory agencies suggest that statins can cause ED, probably by inhibiting the synthesis of steroid hormones derived from cholesterol (Rizvi et al., 2002). Decreased libido has also been reported (de Graaf et al., 2004). One small study showed that 22% of patients experienced new onset ED upon starting statin therapy; this was more likely in patients with severe endothelial dysfunction owing to established cardiovascular risk factors (Solomon et al., 2006).

Patients with psychogenic impotence often have normal morning erections, and they may perform satisfactorily with certain partners. The sensitivity and specificity of certain clinical characteristics associated with psychogenic impotence are given in Table 3.4.

If the patient has a sleeping partner, he can ask his partner whether nocturnal erections occur. If the answer is in doubt, the patient should be instructed to place a roll of about four postage stamps (the old-fashioned kind with perforations) *snugly* about the circumference of his penis upon retiring to sleep. The end stamp can be moistened to fasten the roll. If the circle of stamps splits at the perforation during the night, one knows that nocturnal tumescence has probably occurred and that psychogenic impotence is the most likely diagnosis. This simple and inexpensive "home-monitoring" test has been criticized as being too inaccurate for clinical use (O'Keefe and Hunt, 1995), and these days perforated stamps may be impossible to find. However, clinicians in India found the test invaluable for reassuring patients as well as for predicting improvement with relaxation or behavioral therapy (Das et al., 1993). A $12 Snap-Gauge device may be superior with a sensitivity of around 90% and a specificity of 40% to 50% in a small study. False positives for psychogenic impotence have occurred with pituitary adenoma or sensory neuropathy; the latter may increase latency to

TABLE **3.4** *Sensitivity and specificity of characteristics of psychogenic impotence in 67 patients*

	Psychogenic disease	
Characteristic	**Sensitivity**	**Specificity (%)**
Normal early morning erection	52	100
Sexual erection of good quality, not maintained	27	100
Sudden onset	30	76
No current illness	90	76
No medications	94	41

From O'Keefe M, Hunt DK. Assessment and treatment of impotence. *Med Clin North Am.* 1995;79(2):415–433, with permission.

erection during sexual activity but have no effect on nocturnal erections (O'Keefe and Hunt, 1995).

One study found 65% of cases of impotence to have a mixed etiology, neurologic plus vascular, or psychogenic plus a mild vascular disorder (Collins et al., 1983).

For more details, consult Chapters 18, 21, and 26.

Frigidity

A Sexist Disclaimer

There is no large section on frigidity in this work to match the one on impotence in men. This is because frigidity does not have the same broad semeiophysiologic significance (in terms of the vascular, neurologic, and endocrine systems) as does impotence in men. This is not to say that frigidity is always of cerebral origin (Levine, 1977). It can definitely be conditioned from dyspareunia, which in turn could be due to local factors, some of which might have an endocrine (i.e., estrogen deficiency) basis. It is simply that Leriche syndrome, for example (see Chapter 18), in women is not accompanied by frigidity. An excellent protocol for investigating the complaint of frigidity is available (Levine, 1976).

Gynecologic Symptoms

Abnormal Menses

Abnormal menstrual periods are of several general types. Hypermenorrhea or menorrhagia means excessive or prolonged flow. The average amount of blood loss is from 25 to 70 cc over 3 or 4 days. The patient generally describes this in terms of number of pads or tampons, from which it is very difficult to estimate the actual amount of blood but which may be useful for comparison with the patient's customary pattern. The cause of change may be systemic disease, such as leukemia, or gynecologic disease, such as a uterine leiomyoma or malignancy.

Irregular bleeding is called *metrorrhagia*. This often signifies anovulatory cycles. Menometrorrhagia means irregular and excessive bleeding.

Amenorrhea means the absence of menses, and oligomenorrhea means scant menses. Amenorrhea should be characterized as primary (if the patient has not experienced menarche) or secondary (if she has had menstrual periods that have now ceased).

Intermenstrual bleeding should raise suspicion of a cervical or endometrial polyp or malignancy or an infection. Some staining may normally occur owing to endometrial breakdown at the time of ovulation (Kistner, 1986).

Pain

Pain associated with menstrual flow is called *dysmenorrhea*. Severe dysmenorrhea may result from endometriosis, as the ectopic endometrial tissue bleeds into the peritoneum or into areas encapsulated by fibrous tissue. Generally, the history is of progressive increase in severity. The soreness in the abdomen and pelvis may be present throughout the month but tends to increase premenstrually or during coitus. Endometriosis in the cul-de-sac or rectosigmoid region may cause pain on defecation or dyspareunia.

Pain associated with ovulation ("mittelschmerz") may be difficult to differentiate from appendicitis or other surgical emergencies. The exact timing of the menstrual periods may be of great diagnostic help.

Infertility

The "male factor" is a common cause of infertility and needs to be ruled out.

Disorders of ovulation account for 10% to 15% of failures to conceive. Generally, the menstrual history will be abnormal (*vide supra*).

In an infertile woman with regular menses, inquire with particular care about past episodes of pelvic inflammation, induced abortions, and symptoms suggestive of endometriosis. An asymptomatic episode of a sexually transmitted disease (STD) can result in infertility; thus, screening sexually active women for chlamydia is very important.

Other Symptoms

Inquire specifically about vaginal discharge or irritation and dyspareunia. Remember that the female organs are wedged between the bladder and the rectum, so gynecologic diseases can present with genitourinary or bowel symptoms.

Urinary Incontinence

Urinary incontinence should be described as to volume and frequency. Simple bladder neck obstruction results in many passages of a relatively small amount, but a neurogenic bladder may result in the rare passage of a very large amount of urine. In men, ask about the force of the stream and difficulty in initiating it. In women, also ask about stress incontinence (i.e., involuntary passage of urine with cough or other mechanisms that increase intra-abdominal pressure).

Tinnitus

Tinnitus simply means ringing in the ears. It is a sensation of a noise, which tends to be present most (but not necessarily all) of the time. Intrinsic tinnitus is most commonly associated with deafness, usually of the sensorineural variety. Tinnitus may be caused by irritation of the auditory portion of cranial nerve VIII or of the external auditory canal, eustachian tube obstruction, otitis media, or disturbances of the vascular supply to the auditory portion of the ear. Tinnitus accompanied by paroxysms of vertigo and deafness occurs in Ménière disease.

Pseudotinnitus or extrinsic tinnitus is caused by something external to the ear (e.g., vascular tinnitus) (Chapters 11 and 18).

Tinnitus may result from cochlear hydrops secondary to acute acoustic trauma. It is important to recognize this early because there is a window of opportunity for treatment to prevent lifelong tinnitus and possible hearing loss (Chapter 11). Ask about time of onset in relation to exposure to loud noises such as gunfire, rock concerts, or use of noisy tools without ear protection.

Tinnitus may be caused by drugs, especially salicylates or aminoglycoside antibiotics. Drugs that may induce tinnitus but that have not been associated with hearing loss include carbamazepine, tetracyclines, antipsychotics, lithium, tricyclic antidepressants, monoamine oxidase inhibitors (MAOIs), antihistamines, β-adrenergic blockers, local anesthetics, and steroids (Moller, 1994).

Medical evaluation must be complete. Metabolic conditions that have been associated with subjective tinnitus include hyperlipidemia, thyroid dysfunction, and vitamin or zinc deficiency (Fortune et al., 1999).

Sleep Disorders

Difficulty sleeping is a common reason for consulting a physician. A detailed discussion is beyond the scope of this text, but a few syndromes diagnosed primarily on the basis of the history are discussed below. Sleep apnea, a very important and underdiagnosed condition, is discussed in Chapter 13.

In taking an initial history in the office, ask how many hours the patient sleeps and how much sleep he needs. Does he take naps, fall asleep at inappropriate times, and awaken early? How many times does he awaken during the night and why?

Disturbed sleep, especially early awakening with inability to go back to sleep, is associated with depression. In patients who are not currently depressed, a sleep disturbance is the best predictor of future depression; for this reason, the prevailing wisdom that insomnia is a result rather than a cause of depression may need to be reevaluated (Reite, 1998).

Insomnia is frequently associated with medical conditions and improves with treatment of the underlying condition. Endocrinopathies, any chronically painful condition, breathing difficulties, or cardiac arrhythmias are especially likely to result in sleep difficulties.

Pediatric sleep disorders are common, affecting up to 25% to 40% of children and adolescents. Researchers are beginning to uncover interactions between sleep and psychiatric disorders, including depression, attention deficit/hyperactivity disorder (ADHD), and autism (Meltzer and Mindell, 2006). Insufficient sleep may make an independent contribution to these pathologies (Gaultney et al., 2005). It has been suggested that treatment of sleep-related limb movement or breathing disorders could eliminate ADHD manifestations (Chervin et al., 1997). It is possible that hyperactivity is a paradoxical response to sleep deprivation in children (Cortese et al., 2005). In fact, the cognitive problems that accompany sleep apnea (wandering attention and memory deficits) may result from death of neurons in the hippocampus, a key memory center, owing to intermittent hypoxia. Sleep apnea is estimated to affect at least 2% of children (Miller, 2004). Thus, a meticulous sleep history is especially important in children with troubling behavior or learning problems.

Restless Legs

The restless legs syndrome is a common condition affecting up to 15% of the population (Evidente and Adler, 1999), up to 35% of individuals over the age of 65 (Milligan and Chesson, 2002), and is diagnosed in up to 20% of patients referred to sleep disorder clinics for insomnia (O'Keeffe, 1996). It occurs in children and is often associated with manifestations attributed to ADHD (Cortese et al., 2005). It is an example of a condition diagnosed exclusively on the basis of the history. The classic description is that of Thomas Willis in *The London Practice of Physick* (1685, p. 404):

> Wherefore to some, when being a Bed they betake themselves to sleep, presently in the arms and leggs, leapings and contractions of the tendons, and so great a restlessness and tossings of their members ensue, that the diseased are no more able to sleep, than if they were in a Place of the greatest Torture.

The primary complaint is an irresistible urge to move the legs. Usually, this is accompanied with unpleasant sensations, variously described as creeping, crawling, tingling, burning, or aching. Walking is the most effective way to relieve symptoms. The condition may be familial and is often associated with a sleep-related disorder called *nocturnal myoclonus*. These patients have neither quinine-responsive night cramps nor hypochondriasis. They may respond to carbamazepine and perhaps clonazepam (see Ekbom, 1960; Montplasir et al., 1985; Telstad et al., 1984), dopamine receptor agonists (Tan and Ondo, 2000), gabapentin (Milligan and Chesson, 2002), and opioids (Silber, 2001). Note that the response to various forms of past treatment is an important part of the history.

Restless legs syndrome may be the presenting feature of iron deficiency, and other underlying conditions (including diabetes mellitus, rheumatoid arthritis, and polyneuropathy) should also be sought. The restless legs syndrome occurs in up to 27% of pregnancies, especially in the presence of folate deficiency (O'Keeffe, 1996).

The restless legs syndrome is to be distinguished from akathisia, an inner sense of restlessness with an intense desire to move, not referable to the legs. Akathisia generally results from use of neuroleptic drugs (Tan and Ondo, 2000).

Self-study. What other syndrome or disease would illustrate the principle, here exampled by the restless legs syndrome, of a diagnosis that can only be made by history?

REM Sleep Behavior Disorder

REM sleep behavior disorder (RBD) is characterized by loss of normal voluntary muscle atonia during rapid–eye-movement (REM) sleep so that there is excessive motor activity during dreaming. It is important to recognize this condition because measures need to be taken to ensure the safety of the patient and bed partner.

The posttraumatic stress disorder (*vide infra*) is associated with the development of RBD (Reite, 1998). Additionally, a high percentage of RBD patients have a neurodegenerative disease, especially Parkinson disease, multiple system atrophy, and dementia (most frequently due to Lewy body disease) (Silber, 2001).

Parasomnias

Parasomnias are unusual behaviors that occur in the context of sleep. These include somnambulism (sleepwalking) and sleep (or "night") terrors. In predisposed persons, symptoms may be precipitated by sleep deprivation or vigorous physical activity. The differential diagnosis includes psychomotor epilepsy (Reite, 1998).

Narcolepsy

The narcoleptic tetrad is excessive daytime sleepiness, cataplexy, sleep paralysis, and hypnagogic hallucinations, although only 15% to 20% of narcoleptics experience all four elements. One third of narcoleptics have a positive family history.

Hypnagogic hallucinations are vivid auditory, visual, or somasthetic hallucinations that most often appear with sleep onset. This symptom is not restricted to narcolepsy.

The treatment of previously undiagnosed narcolepsy has improved refractory symptoms attributed to schizophrenia (Reite, 1998).

A Philosophical Interlude on "Diseases" and "Syndromes"

Disease is defined by *Dorland's Illustrated Medical Dictionary*, 24th edition, as a definite morbid process having a characteristic train of symptoms. It may affect the whole body or any of its parts, and its *etiology*, pathology, and prognosis may be known or unknown (emphasis mine). It comes from the words meaning "without ease" or "uncomfortable."

Syndrome is defined as a set of symptoms that occur together, the sum of signs of any morbid state, or a symptom complex. It comes from the words meaning "to run together."

To restate the above, a disease is a definite entity with a single etiology. A syndrome is a concurrence of events. A syndrome could occur in many different diseases; for example, malignant hypertension could be a syndrome occurring in the various diseases of pheochromocytoma, renoprival hypertension, polyarteritis nodosa, and so forth.

As the experienced reader may have guessed, many objections could be raised to this formulation. A substance abuser might be considered "nondiseased" and only become symptomatic and hence "diseased" when abstinent, yet we generally consider abstinence equivalent to health. Furthermore, the idea that a disease has only one etiology works well for malaria but not so well for ischemic heart disease in which both mechanisms and etiologies may be diverse.

Do we demote myocardial infarction to a syndrome? And because there are different infarction syndromes, we could end up with a rather complicated outline (see the New York Heart Association Classification of Heart Disease). Notice, in the last sentence, we now have a single disease comprising several syndromes and not a syndrome comprising several parts.

Worse, even when we know the specific etiology of a disease, such as the hepatitis B virus, there are many clinical outcomes that are diverse and not at all "definite" or "characteristic," as Dr Herbert Weiner of Los Angeles has pointed out. These range from an asymptomatic carrier state to aggressive forms of hepatitis, including those in which the body's own immune response produces disease in organs other than the liver (e.g., the kidneys). Thus, while the hepatitis virus is the etiology of one disease that causes the syndrome "hepatitis," the disease itself comprises various syndromes.

The acquired immune deficiency syndrome (AIDS) is now being conflated with "HIV disease," even though the manifestations are protean and also occur in many persons with no evidence of human immunodeficiency virus (HIV), and patients with a positive HIV test may remain healthy.

In summary, with advances in knowledge, we should not be surprised if the defined use of "disease" and "syndrome" become less useful.

Use of Diagnostic Conclusions

You may include the previous diagnostic conclusions of other physicians in the history, provided that you try to establish the basis of the diagnosis and indicate the level of certainty. For instance, a gastric ulcer removed at surgery would be of a higher level of certainty than a gastric ulcer reportedly seen at endoscopy, which would be more certain than a "suspected" gastric ulcer seen on a radiograph, although any of these might be acceptable. A diagnosis of gastric ulcer made strictly on the basis of another doctor's history would not be at a comparable level of certainty, and it might be placed in quotation marks in the write-up. However, if the patient says something like, "I have a gas pain," it is obviously a mistake to accept his diagnosis and record it in the chart, instead of asking something like, "What about it tells you that it is a gas pain?" While we are cautious in accepting the diagnoses of other physicians, we still ask about some of their findings, especially heart murmurs. Of course, this is secondhand information, but when we know that the patient has previously been under the care of competent physicians, we may wish to learn when a murmur (or other finding) was first noted. We again use the technique of bracketing (see Chapter 2), attempting to learn when the physician first heard the murmur as well as a previous time when the murmur was sought but not found.

To illustrate how this information might be useful, consider the usual time of onset of various types of murmur-producing heart disease. Murmurs appearing before the age of 5 tend to be due to congenital heart disease (although mitral valve prolapse and some other congenital lesions may not become evident until later in life, *vide infra*). Murmurs appearing between the ages of 5 and 15 are usually caused by rheumatic heart disease; those appearing between 15 and 30 are usually due to mitral valve prolapse; and those first heard after age 30 are most likely to result from idiopathic hypertrophic subaortic stenosis or bicuspid aortic valve stenosis (congenital lesions with tardy manifestation). While using these clues, do not slavishly surrender your good judgment to them. More than one cardiologist has inherited a patient diagnosed as mitral stenosis who turned out to have an atrial septal defect. Of course, none of these rules apply if the patient has not been examined regularly and competently or has bacterial endocarditis.

Past Medical History

Traditionally, this section contained a list of the patient's past medical and surgical hospitalizations. With changes in the use of hospitals resulting from payment policies of government and managed-care organizations, it may be necessary to modify the past medical history to include important illnesses (not symptoms) that were evaluated in ambulatory care.

Students are frequently confused about what belongs in the past medical history and what goes in the review of systems. As a rule, all hospitalizations and major medical events go in the past medical history. These will usually be listed by the date, name, and location of the hospital, and diagnosis or operation, as outlined in Chapter 4. The review of systems, on the other hand, is a review of all the symptoms pertinent to a particular system.

The past medical history should correlate with the physical examination. If the patient tells you of an operation, he should have a matching scar; conversely, if you find a surgical scar, you need to review the history. Sometimes patients forget about an operation until the scar reminds them. This may also be a clue to the presence of an organic brain syndrome (see Chapter 2).

Immunizations

The past medical history also includes immunizations, which have greatly increased in number. The childhood immunization schedule, like the pediatric examination, is traditionally taught during the pediatrics rotation, not the first course in physical diagnosis; this text focuses primarily on the adult.

Tetanus immunizations should be updated every 10 years, or in five if a patient presents with a dirty wound. A hospitalization or new-patient visit is an opportune time to check on the need for a booster or even the primary series. According to a serologic survey conducted in 1988 to 1991, the prevalence of immunity to tetanus drops from 80% in persons aged 6 to 38 years to 28% among persons aged 70 or older. *Clostridium tetani* is ubiquitous in the environment. Only 41% of US patients sought medical treatment for the injury that resulted in the infection. In 29 nonneonatal cases in the US between 1995 and 1997, unrelated to an acute injury, patients had an underlying condition such as a chronic wound or intravenous drug abuse (Bardenheier et al., 1998).

Other immunizations that adults may receive under certain circumstances include diphtheria (with tetanus), pneumococcal, meningococcal, rabies, rubella, hepatitis A or B, RhoGam (for Rh negative expectant mothers), and influenza. World travelers and military personnel may have received yellow fever, typhoid, cholera, anthrax, or smallpox vaccines. Because naturally occurring smallpox was eradicated worldwide, it has been said that it is no longer necessary to inquire about smallpox vaccinations. Concerns about biowarfare, however, have brought back vaccinations of some at-risk groups, and statements have been made about possibly enduring immunity in persons vaccinated before routine vaccinations were stopped in 1972.

It is important to have a complete immunization record in the patient's chart. Always remember, however, that while immunization reduces the probability of a vaccine-preventable disease, it does not rule it out, and manifestations may be atypical.

If a patient believes that he has had a serious adverse reaction to a vaccine, ask whether it has been reported to the Vaccine Adverse Event Reporting System, a passive surveillance system maintained jointly by the Centers for Disease Control and Prevention (CDC) and the Food and Drug Administration (FDA). Patients can file reports themselves.

Social History

The information that should be included in the social history is given in Chapter 4, in the outlines for the case record. Some questions used to elicit the social history are as follows:

"What do you do on your day off?" or "What do you do on a typical Sunday?" (Dr Lawrence Weed of Ohio liked to identify what the patient did on an average day, but that part of the Weed database was the first part to be omitted.)

"When was the last time you took a vacation?"

"What happened to your hobby?" This is an open-ended question because at the time that it is asked, one does not know that the patient has discontinued an earlier hobby or, for that matter, that he has ever had a hobby.

"What do you do for fun?"

"Who cooks for you when you are sick?"

It is essential at the first interview that the physician determines what sort of ego defenses the patient uses and what sort of social support systems the patient has available. If this information is readily at hand, it will help the physician convey catastrophic news in the least noxious and disruptive manner should this become necessary.

In the absence of formal training in the assaying of ego defenses, the physician can simply ask, "What is the worst thing that ever happened to you?" and then listen attentively to the patient's description of how he dealt with it. To learn about social support systems, the physician should ask, "To whom would you go if you had a really terrible problem you could not deal with alone?" Many people with no apparent support systems have good answers, and many people with multigenerational families and intact marriages surprisingly can name no one. Assume nothing, and be prepared.

If the patient has had a particularly traumatic experience (e.g., being held as a hostage, a prisoner of war, or a political prisoner), he should specifically be asked to recount that experience. You specifically need to know about torture so that you do not unintentionally evoke associations to that experience.

Posttraumatic Stress Disorder

With reference to an episode at the Battle of Marathon in 490 BC, Herodotus may have been the first to describe what might now be called a posttraumatic stress disorder (PTSD) (Swartz, 2002). (See the epigram in the "Ocular Malingering and Ocular Hysteria" section of Chapter 10, where Dr Sapira suggested the diagnosis of a conversion reaction.)

Previously called *shell shock* or *battle fatigue*, and diagnosed primarily in those who had experienced wartime conditions, the scope was greatly broadened in 1987 by the American Psychiatric Association (APA) in its Diagnostic and Statistical Manual of Mental Conditions (DSM-IIIR). PTSD may now be diagnosed in survivors, rescue workers, and friends or relatives of victims of any traumatic event. A traumatic event, according to the definition on the web site of the CDC, is "characterized by a sense of horror, helplessness, serious injury, or threat of serious injury or death."

The spectrum of events described by the APA ranges from combat and torture to violent personal assaults, natural or man-made disasters, automobile crashes, and being diagnosed with a life-threatening illness. In the 1980s, feminist therapists sought to have the definition expanded to include routine and repeated experiences, from sexual abuse and exploitation to "sexual harassment" or conflicts with men on the job (Showalter, 1997).

The classic symptoms of shell shock are recurrent, intrusive recollections (flashbacks), often associated with triggering events such as anniversaries; recurrent nightmares; avoidance of reminders; a persisting sense of "numbness" or emotional blunting ("psychic numbing"); detachment from other people; anhedonia; autonomic hyperarousal with hypervigilance, an enhanced startle reaction, and insomnia; in rare cases, outbursts of fear, panic, or aggression; and a sense of a foreshortened future.

A laundry list of cognitive, emotional, physical, and behavioral symptoms may be attributed to a traumatic event.

The lifetime prevalence estimated from "community-based studies" is stated by some to be as high as 14%, astonishingly high outside a war zone.

Some Caveats

Students and physicians should exercise appropriate skepticism and caution regarding "new" diseases with political ramifications, a proliferation of Internet sites and therapists, and sponsored web sites such as the "Car Accident Lawyer Network" (which pops up in an AltaVista search on "posttraumatic stress").

As the DSM-IV notes, "malingering should be ruled out in those situations in which financial remuneration, benefit eligibility, and forensic determinations play a role." (See Chapter 2, the section headed "The Patient Who May Have Other Legal Involvements.")

The diagnosis of PTSD is increasing in parallel with the social pathologies likely to cause trauma—crime, child neglect, broken relationships, and domestic violence. Newer textbooks exhort students to ask all patients whether they have been "emotionally, physically, or sexually abused" (Swartz, 2002). (Physicians need to be aware of statutory reporting requirements for abuse [*vide infra*].)

Remember that diagnostic labels can affect the way patients think about themselves. PTSD is the one diagnosis in the DSM-IV that identifies the origin of symptoms as an event external to the patient (Swartz, 2002). In other words, the patient is unequivocally a victim.

Patients who see themselves as putty in the hands of fate, rejecting Bacon's dictum that "chiefly the mould of a man's fortune is in his own hands," could become caught in a trap of lifelong victimhood. They may also victimize others.

British psychiatrist Anthony Daniels, writing under the pseudonym Theodore Dalrymple, believes that the rampant social pathologies once attributed primarily to the "underclass"—now proliferating in all socioeconomic strata—result from a worldview that denies personal responsibility (Dalrymple, 2001). His insights, gleaned from some thousands of patients in hospital in a British slum and a nearby prison, are well worth reviewing. One lesson is the prognostic value of knowing the patient's view of himself as a passive victim or active agent.

Is "Shell Shock" a Traumatic Brain Injury Due to Blast?

During World War I, physicians considered "shell shock" to be a sign of mental weakness or "lack of moral fiber." It is increasingly evident, however, that many of the symptoms and signs are those of traumatic brain injury (TBI). Soldiers with a history of blast exposure, even without apparent head injury, are far more likely to exhibit cognitive and behavioral abnormalities and to have abnormal brain activity on electroencephalograms (EEG). Insomnia, vertigo, memory deficits, irritability, depression, and very short attention spans are common manifestations. Abnormal EEGs were found in 36% of soldiers with blast injuries compared with only 12% of those injured by projectiles. The U.S. Defense and Veterans Brain Injury Center estimates that 10% to 20% of all soldiers serving in Iraq or Afghanistan have suffered some form of TBI (Bhattacharjee, 2008).

Early experiments that exposed animals to blast showed air emboli in coronary and carotid arteries. Blast subjects the organism to a wave of overpressure followed by underpressure, a rapid compression/decompression. Thus, blast injury may be a form of decompression sickness comparable to that experienced by divers. Showers of air emboli have been detected by Doppler as long as 30 minutes after blast exposure; they may be absorbed after death and thus not be seen at autopsy (Sharpnack et al., 1989). On this basis, early hyperbaric therapy has been recommended for persons with neurologic deficits after blast exposure (Phillips and Zajtchuk, 1989), and early air evacuation may worsen the condition. (Divers are advised not to fly for some period after decompression.)

Supportive of this mechanism (which is not mentioned in the study) is a survey of soldiers returning from Afghanistan and Iraq in 2003 (Hoge et al., 2004). The prevalence of PTSD by a strict definition increased in a linear manner with the number of firefights (and hence blast exposure) experienced. For soldiers deployed to Iraq, the prevalence was 4.5% for no firefights, 9.3% for one or two, 12.7% for three to five, and 19.3% for more than five ($P < 0.001$ for a linear trend). For those deployed to Afghanistan, the rates were 4.5%, 8.2%, 8.3%, and 18.9%, respectively ($P < 0.001$).

Religion and Culture

The patient's religion, or basic philosophical assumptions, is very important in his perception of illness and response to it. Dietary practices, remedies, and taboos (such as refusal of blood products by Jehovah's Witnesses) may be integral parts of the patient's religion or culture.

The diversity of beliefs and customs is so great as to defy attempts to capsulize them. Even different Indian tribes in one small region may have belief systems that are radically different from each other as well as from Western concepts. Styles of human interaction (eye contact, social distance, acceptable touching) may impede communication or cause inadvertent offense. Students need to learn about the culture of the people they serve, preferably from persons who speak the language and have regular interaction with both the patients and the prevailing culture.

Sexual History

Many would consider the sexual history to be a subsection of the social history, but the questions asked are like those that one asks about any other organ system. The customary dimensions are useful: quantity, quality, chronology, setting, aggravating factors, and alleviating factors. One needs to determine the patient's preferences and actions in terms of object, frequency, and mode, and whether the patient feels good or bad about his sexual activities, and in what specific ways.

In no other sphere is adjectival labeling so potentially misleading, as illustrated by the following case:

A 68-year-old male veteran was admitted 25 years after a bilateral adrenalectomy, which was followed by the appearance of sellar enlargement and bitemporal hemianopsia. The patient shaved every other day, had a female escutcheon, and lacked axillary hair. The house staff was unwilling to accept the diagnosis of hypogonadism because the patient was "sexually active." On further inquiry, it was learned that this sexual activity consisted of cunnilingus with his wife about once a month. Testosterone and gonadotrophin levels later were found to be subnormal.

A history of STDs is obviously of great importance. The global question, "Have you ever had a sexually transmitted disease?" will have many false negatives because fewer than a quarter of adolescents at high risk know that they have been treated for a STD (Fleisher et al., 1991). This is especially true for those who have

been treated for chlamydia, trichomonas, and venereal warts (McHugh and Palusci, 1992). Be sure to ask about herpes, "yeast infections," "warts," and "crabs." The absence of a history does not rule out an infection, as many cases are asymptomatic or have transient manifestations attributed to something else. It is imperative to ask about all partners, as they must also be treated.

By law, some STDs must be reported. Different rules may apply to the HIV. Physicians need to inform themselves about the law in their jurisdiction.

Physicians such as campus psychiatrists, consulted by increasing numbers of young persons, especially women, with depression, eating disorders, sleepless nights, or relentless worrying, must be aware that an STD or abortion could have triggered the symptoms and must ask about them specifically. Physicians should also be open to the possibility of adverse emotional and spiritual consequences of a pervasive culture of casual "hookups" (Grossman, 2006).

Sexual History in Women

Is the Patient Pregnant?

The possibility of pregnancy must *always* be kept in mind from the outset for women of childbearing age because it affects all diagnostic and treatment decisions. Therefore, premenopausal women should be asked the date of their last menstrual period, at every office visit. The physician should also ascertain whether the flow occurred on time and was otherwise normal and whether any recent menses have been abnormal or skipped.

Occasionally, menstrual flow still occurs during the early months of pregnancy. So the occurrence of periodic bleeding does not absolutely rule out pregnancy. Furthermore, the most recent episode of bleeding might be the result of an obstetric complication, such as a tubal pregnancy, rather than a normal menstrual period. This is especially important in women presenting with abdominal pain.

Other symptoms of pregnancy include nausea, unusual fatigue, and breast soreness. Women who present with symptoms suggesting pregnancy should be asked whether they have been pregnant before and whether they felt the same way then.

Reproductive History

Of course, the sexual history (*vide supra*) should be obtained, including the type of contraception employed, if any. In a patient who might be pregnant, the past history of pelvic inflammatory disease is especially important because it increases the likelihood of an ectopic pregnancy with its potential for catastrophe.

Ask whether the patient has been an egg donor. The patient might have been told that there were no "known" long-term consequences, and she might not think to mention it. The ovarian hyperstimulation might make a number of cancers more likely, including colon cancer as well as cancers generally recognized as being estrogen-sensitive (Calderon-Margalit, et al., 2009; Schneider, 2008).

The number of pregnancies (parity), the number of births (gravidity), and number of abortions—spontaneous ("miscarriage") or induced—should be obtained. A patient who has had one pregnancy and the birth of twins would be P 1, Gr 2. A patient who has had five pregnancies, given birth to three children, and had two induced abortions would be P 5, Gr 3, Ab 2. The number of stillbirths (a red flag for potential problems) is indicated by SB.

Make a note of any premature births or complications of pregnancy, such as gestational diabetes or preeclampsia.

Ask about the gestational age in any abortions, the patient's age at the time, and which pregnancy was involved, as these may be relevant to the risk of breast cancer (see Chapter 15). Induced abortion, particularly multiple terminations, is associated with an increased risk of later premature births and is an indication for intensified prenatal care (Rooney and Calhoun, 2003). Ask whether fetal tissue was examined for chromosomal anomalies, especially if the patient has had more than one spontaneous abortion. Another reason for pathologic studies is that molar or partial molar pregnancies require special follow-up (C. Hyland, *personal communication*, 2004).

A newly appreciated reason for a complete pregnancy history is that women become chimeras following pregnancy, regardless of its outcome. Up to 500,000 nucleated fetal cells enter a woman's circulation following a routine surgical abortion. Thus, stem cells or tissues obtained from a woman who has been pregnant are likely to contain a mixture of her own cells and those of her fetuses. These fetally derived cells may be implicated in the pathogenesis of autoimmune disease, or they may have a beneficial effect in the repair of maternal disease or injury. They are likely to be very important in transplantation (Bianchi and Fisk, 2007).

The subject of abortions should obviously be approached in a sensitive, nonjudgmental manner. For almost all women, it is a painful experience and, for many, life altering. The APA removed abortion from the list of psychosocial stressors that are acknowledged to be possible causes of a PTSD (*vide supra*), on publication of the DSM-IV (Burke and Reardon, 2002). Nevertheless, there are support groups for women who report postabortion emotional symptoms compatible with PTSD, some long delayed. While some say that postabortion stress syndrome does not exist, there are nearly 2 million postings to message boards of the website www.afterabortion.com, which take no political or religious stand on abortion.

With more than 1 million abortions occurring annually in the US, tens of millions of women have had this experience, and thus any sequelae are numerically significant. Political considerations have impeded research and reporting about the complications of legal abortions. The highly significant discrepancies in complications reported in European and Oceanic Journals compared with North American journals could signal underreporting bias in North America (Ring-Cassidy and Gentles, 2002). Adverse reactions, important for obtaining informed consent for abortions as well as for treating postabortive patients, include depression, grief and loss reactions, suicide, eating disorders, substance abuse, increased rates of smoking, relationship problems, and child abuse (Burke and Reardon, 2002; Strahan, 2001). British authors of a major review concluded that "marked, severe or persistent" psychological or psychiatric disturbances occur in approximately 10% of women who have abortions (Zolese and Blacker, 1992). A Finnish study discovered a suicide rate among women who aborted nearly six times as great as among women who delivered their babies (Gissler et al., 1996, 2005).

Are the purported links coincidental, or the result of preexisting dispositions in women who choose abortion? Students need to

be aware of the controversy, as abortion may be a marker for risk, even if it is not the cause. The best advice, as usual, is to *listen to your patients*.

There is probably no area in which assurance of confidentiality is more important to ensuring honest communication, as abortions may have been concealed from parents, husband, and children.

A History of Abuse

Abuse of wives, sexual partners, children, and elders is stated to be "rampant" (Swartz, 2002), and concerns have resulted in well-intentioned reporting requirements for physicians. All physicians, especially those who work in emergency departments, need to be familiar with the legal requirements. Equally important is awareness of the harm that can follow a report of an ill-founded suspicion. As will be elaborated in appropriate parts of this book, findings attributed to abuse have a differential diagnosis. A careful history and physical examination can lead to a correct diagnosis and appropriate treatment, preferably before the precipitous involvement of law enforcement and social services has disrupted families and impeded potentially lifesaving medical treatment.

Unusual conditions and the use of folk remedies produce signs that can be mistaken for child abuse, but in one series of cases, involving inner-city residents, it was the "usual" that was misinterpreted. The final diagnoses included meningitis and sudden infant death syndrome. The authors noted that the hospital staffs were unfamiliar with expected postmortem changes. They had failed to take a careful history or to believe the parents' story, failed to properly consider nontraumatic etiologies, and displayed an attitude of hostility toward the parents.

"When the stress of losing a child is compounded by false accusations of child abuse, verbal threats, or police detention, this becomes a form of medical abuse" (Kirschner and Stein, 1985). Physicians need to maintain their professional objectivity, obtain expert consultation promptly, and focus first on conditions, such as sepsis and meningitis, that may need and respond to lifesaving intervention.

When a child has died, or after his immediate needs have been attended to, interview (do not interrogate—see Chapter 2) parents or caregivers carefully and nonjudgmentally. Avoid leading questions, such as "You shook the baby, didn't you?" Do not omit the vaccine history, the dietary history, symptoms of presumed minor illnesses, and the use of prescribed or nonprescribed remedies. Take time to listen.

In the case of adults who may have been abused, ask the patient directly, gently, and in complete privacy. Offer a referral to a battered women's shelter, a social service agency, or other source of aid. If the patient declines, ask why. Some battered women have contributed to their fate by their life choices, according to Daniels, who states that "the battered-woman-syndrome concept is uncompromising in its rejection of personal responsibility" (Dalrymple, 2001). Unless the patient is ready to make some changes in her life, attempts at intervention may prove fruitless. The physician should provide, in any case, a list of hotline numbers before ending the visit, even if the patient is not ready to use them.

Drug History

The physician must know about all the patient's medicines: those that were prescribed by the physician, those which the patient obtained over the counter, and those that were taken for recreational purposes. Some women do not consider birth control pills to be medicines or drugs and must be specifically asked about them.

Prescription Drugs

The important descriptors for drugs include the route, dose, and the frequency. One may wish to add the duration. And of course one always wants to comment on how the patient is actually taking the medication (as opposed to recounting the directions on the bottle). This aspect is often referred to by the misnomer "compliance." The word "compliance" may be stamped on the form that one must submit to the motor vehicle division to certify that one's automobile meets the standards for emission controls. It is very frequently used in the context of adherence to the dictates of an authority. In medical contexts, it should be eschewed. The physician should remember that the patient is only purchasing advice, not an order or an instruction to which he must conform.

Over-the-counter Medications

Sometimes the patient does not consider over-the-counter products worth mentioning, but his symptoms could be side effects of such medications, particularly the anticholinergic effects of antihistamines or the gastrointestinal irritation caused by aspirin or nonsteroidal antiinflammatories. You should specifically ask about any such drugs that come to mind.

A Case History

A physician noted an annoying sour taste in his mouth, along with cramping in his feet that he considered to be unrelated. His oncologist recommended an antacid and elevating the head of the bed for presumed gastroesophageal reflux. These measures made no difference in his symptoms.

Then the physician, aided by an Internet search, made his own diagnosis: Toxicity from bismuth subsalicylate (Pepto-Bismol). He had been taking this in tablet form twice daily to control the soft stools resulting from the proton pump inhibitor prescribed by his oncologist. He might have recognized the sour taste had he been using the liquid form. The cramps resolved, and the taste disappeared after about 3 months. Weakness, tremors, spasms, seizures, symptoms imitating Creutzfeldt–Jakob disease, and even death have been reported following chronic use of this over-the-counter preparation.

Herbal Remedies and Nutritional Supplements

The patient may not think to report vitamins, herbs, folk remedies, and "nutritional supplements," which he might be taking in toxic amounts or which might interact with prescription drugs.

The percentage of Americans visiting an "alternative medicine practitioner" increased from 33.8% in 1990 to 42.1% in 1997. In both years, less than 40% of the patients disclosed their use of alternative therapies to their regular physician (Eisenberg et al., 1998).

The issue of unorthodox remedies requires tactful handling, just as the problem of "compliance" does. Many patients have experienced

anger or condescension from their physicians when they have admitted to taking remedies from the health food store or the "natural healer." You need to examine your own attitude toward such remedies, as it may prevent the patient from providing history that you need for optimal treatment. Resorting to "quackery" is a normal human tendency, not a sign of personal rejection of the physician. Patients desperately need hope, and the therapeutic value of "doing something" should never be underestimated.

Physicians trained in "orthodox" therapeutics should also keep their minds open to the possibility that the out-of-pocket expenditure of $27 billion per year for alternative remedies, which is comparable to out-of-pocket spending for all US physician services, is buying something more than a placebo. Remedies that have not been subjected to a randomized controlled trial may still be effective. An example to ponder is that folic acid supplementation in pregnant women, now considered essential to prevent neural tube defects, was forbidden in the 1970s; this vitamin could be obtained only from nonmedical sources (A.B. Robinson, *personal communication*, 2004).

Managing the issue of unorthodox remedies illustrates the importance of a therapeutic alliance between patient and physician, as opposed to an authoritarian approach. Physicians need to instruct their patients on how to evaluate medical advice and should also be ready to learn from patients, if only to prepare to give appropriate warnings.

In obtaining a drug history, remember that substances applied to the skin may be readily absorbed. The patient may not consider skin creams to be drugs. One mysterious cause of mercury poisoning near the Mexican border of Arizona was found to be a secret "beauty" cream called Mannings *Crema de Belleza* in which the main ingredient is calomel (mercurous chloride). Millions of bottles are sold in Latin America, and women may use one to four bottles a month (Boyer, 1996).

Dimethyl sulfoxide, an organic solvent, is popular in "alternative medicine" circles because of its antiinflammatory effects. It has the characteristic of transporting other substances through the skin as well.

It is worth reiterating that in all these inquiries, you need to communicate to the patient that the purpose of the inquiry is to obtain information so you can help him better, not to gather evidence for an indictment.

Illegal Drugs

The information we need about the patient's use of what our culture euphemistically calls "recreational drugs" is the same as is required for his prescription drugs. We need to know exactly what drugs are being taken, the route, and the dosage interval. We need a detailed history for the last week, in the event that the patient is taking a drug with a recognized withdrawal syndrome. Specifically, we need to know precisely when a narcotic analgesic or a sedative–hypnotic was stopped because withdrawal may be akin to the abrupt stop at the pavement after a person has jumped off a building. The daily dose prior to the withdrawal is analogous to the height of the building.

If the patient dissolves oral medications and takes them parenterally, another frequently unappreciated question must be asked. The inert filler added for bulk during the manufacture of both legal and illegal drugs includes talc and starch. When these are injected, they form microemboli throughout the body, first in the lungs, where their cumulative effect is a disease known as angiothrombotic pulmonary hypertension, sometimes called "blue velvet lung." These microemboli can also reach systemic circulation. They have been seen *in vivo* in the eyes and at autopsy in the spinal cord, kidneys, and other organs. Their presence in the brain is inferred from neurologic findings.

Thus, if you determine the patient to be an intravenous drug user, you must ask, "When you shake the drugs up, or dissolve them in a spoon or cap, are they perfectly clear?" or "When you look through the barrel of the syringe before you inject, is it perfectly clear like water, or is it cloudy?" or "Could you read a newspaper through it? Is it that clear?"

If the material is not perfectly transparent, then there is obviously something that is not solubilized. (For a more complete discussion, see Sapira and Cherubin [1975].)

Dietary and Nutritional History

Dietary therapy dates back to ancient times and is very prominent in folk medicine and "complementary" medicine. Proper diet is crucial for health and must not be neglected in mainstream medical practice.

The modern epidemics of diabetes and heart disease have an important dietary component. Obesity is epidemic in America; some say it may result partly from starvation in the midst of plenty or overeating in an attempt to compensate for a diet deficient in essential nutrients. A whole panoply of symptoms may be attributed to food allergies or intolerances, which may paradoxically be manifested by a craving for a particular food. While this problem may be overemphasized by unorthodox practitioners, a significant fraction of the population is lactose intolerant, and many persons without overt celiac disease do better on a gluten-free diet. Life-threatening anaphylaxis may be caused in some persons by ingestion of certain foods, peanuts, and shellfish being the most common offenders.

Orthodox physicians are often accused of ignorance about nutrition. Be sure that the accusation is not merited in your case!

Ask what the patient eats on an average day. Are there food intolerances or cravings? Has the patient ever followed a particular diet? How carefully? For how long? Why was it stopped? What were the results? Has the patient been reading diet books? Which ones? What is the lifelong pattern of weight? What did the (older) patient weigh at age 20? How much would he like to weigh? How often does a patient eat a home-cooked meal? How much artificial sweetener is used? What type? What beverages are used and in what amount? Does the patient (or the person who shops for the family) read labels in the supermarket?

Vitamin deficiency diseases still occur, even in the US, and will be described in succeeding chapters.

The student should be aware that there is more to nutrition science than the FDA's Food Pyramid. The cholesterol hypothesis of heart disease, though currently established doctrine in the US (Stamler and Neaton, 2008), is not universally accepted (Colpo, 2005; Kauffman, 2004; Peskin et al., 2008; Ravnskov, 2003, 2008; Weinberg, 2004). The orthodox "heart-healthy" diet, promoted with the help of the U.S. federal government for more than

40 years, could be worse than ineffective. Some believe that the high level of carbohydrates, especially fructose, and the imbalance in fatty acids in vegetable fats play a causative role in the modern epidemics of heart disease, obesity, and type 2 diabetes (Ottoboni and Ottoboni, 2002, 2007). Substantial changes in the American diet have occurred since 1909, and even since 1970. Dietary sugar has increased by 24% and total dietary fat by 32% since 1970, while saturated fat consumption has remained nearly constant for 90 years (Cordain et al., 2003).

It is impossible to predict what the state of the science of nutrition will be at the time the student is reading this book. But the principles will still be valid: obtain the history, do not overlook the obvious, and monitor the patient.

A detailed dietary history will include information about omega-3 and omega-6 fatty acids. These are the two families of essential fatty acids. These are key building blocks for brain and nerve tissue and the hormonelike messenger chemicals called *eicosanoids*. The latter are involved in blood clotting, immunity, inflammation, pain, and blood pressure regulation.

The terminal carbon in a fatty acid chain is called the omega carbon, and the number after the omega refers to the carbon at which double bonds begin, with the omega carbon being number 1. α-linolenic acid is an essential omega-3 fatty acid, and linoleic acid an essential omega-6 fatty acid. A proper ratio of omega-6 to omega-3 is said to be 5:1 or less, much less than the usual 20:1 estimated for the typical American diet.

The only rich dietary source of omega-3 fatty acids is fish, especially cold-water fish (anchovies, halibut, mackerel, salmon, and sardines). They are also found in small quantities in green leafy vegetables, in unrefined olive oil and canola oil, and in beef and pork flesh. They are abundant in flaxseed oil, often recommended as a nutritional supplement. Omega-6 fatty acids, on the other hand, are abundant in the vegetable oils commonly sold in the US, such as safflower, corn, cottonseed, soybean, canola, and peanut oils.

There is increasing concern about trans fats, which result from the partial hydrogenation of vegetable oils to increase shelf life. Labels may use the term "vegetable shortening." New food labels may state the content of trans fat. Trans fats interfere with essential fatty acid metabolism and raise blood glucose and "bad" cholesterol (low-density lipoprotein [LDL]) levels. They may contribute to low birth weights and decrease visual acuity through transmission in breast milk (Ottoboni and Ottoboni, 2002).

Aficionados of the Internet will be aware of raging concerns about food additives, including monosodium glutamate (MSG) and aspartame.

MSG, which causes the "Chinese restaurant syndrome," is found as a flavor enhancer in many processed foods and is often called "natural flavorings," "hydrolyzed vegetable protein," "yeast extract," "textured protein," "gelatin," or something else on the label. It is one of a large number of compounds, including essential endogenous neurotransmitters, called "excitotoxins," which, in excessive concentrations, induce neuronal death. Extensive references to the scientific literature concerning the role of excitotoxins in neurodegenerative diseases are given in a popular book (Blaylock, 1997). Although glutamate enters the brain only by active transport and concentrations in the brain are kept low and independent of plasma levels, certain areas of the brain such as the hypothalamus lack blood–brain–barrier protection (Smith et al., 2001).

There is substantial evidence that glutamate is a neurotransmitter in the enteric nervous system and that overactivation of enteric glutamate receptors may contribute to intestinal damage from excitotoxins in food (Kirchgessner, et al., 1997). Gastrointestinal dysfunction may result from excitotoxins in food (Olney, 1994).

A long list of symptoms has been attributed to aspartame. Here is one item that demonstrates the importance of a quantitative history, even of FDA-approved compounds: The dose makes the poison. One woman has been convicted and sentenced to 50 years in prison for allegedly murdering her husband with methanol (Roberts, 2003). His dietary history included consumption of 10 cans of aspartame-containing sodas per day, and the defense was unaware that methanol is a breakdown product of aspartame. Other food items, such as fruit juices, also contain trace amounts of methanol but in combination with small amounts of ethanol, which is protective.

A detailed food diary can help elucidate the connection between symptoms and intake. The effect of exclusion can be monitored; this is not necessarily easy to accomplish. MSG, for example, is nearly ubiquitous in processed foods. In addition to reading the labels, patients may need to call the manufacturer to determine whether MSG is present in a particular product. The effort may pay off: Four patients who had suffered symptoms diagnosed as fibromyalgia for 2 to 17 years had improvement or resolution with elimination of MSG and aspartame and recurrence upon rechallenge (Smith et al., 2001).

A Note to the Student

There is too much detail in this chapter for you to assimilate it all into your routine history. Accordingly, you should review the appropriate parts of this chapter, depending on the patients you are seeing.

In your senior year, reread the section on the interviewing process, and use a tape recorder, even if you have already done so. Most physicians need the satisfaction of observing a significant improvement in their physical examination skills before they can relax enough to utilize some of the lessons to be learned from auditing themselves with patients.

As you're developing your differential diagnosis while eliciting and structuring the patient's story, take care to avoid some common cognitive traps: availability error, attribution error, and anchoring error. These are elaborated by Jerome Groopman in his book *How Doctors Think*, well worth reading though directed to laypersons. (In fact, if your patient has read it, you are likely to find your job much easier!)

Availability means judging the likelihood of an event by the ease with which examples come to mind, perhaps because of recent cases you have seen. Attribution error means to stereotype the patient, say as a complainer or hypochondriac, and attributing her persistent symptoms to this benign condition. Anchoring error means to seize on an initial symptom, make a snap diagnosis, and then cherry-pick data that agree with it—a process also known as confirmation bias—instead of considering multiple possibilities (Groopman, 2007).

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CHAPTER

4

The Case Record

Mephistopheles: I'll wait on you tonight, when you partake
Of college gaudy, where the doctors dine;
Only—since life, or let's say death's at stake—
I'll bring you back, please, a couple of lines to sign.
Faust: So, black and white you want? You've never heard
Good pedant, that a man may keep his word? . . .
A parchment, notwithstanding, signed and sealed,
Is bogey fit to make the bravest yield.

—Goethe (translated by Philip Wayne). *Faust: Part I*: The Study (3)

Points to Remember:

- The medical record is also a legal document. Never alter it without clearly signing and dating the changes.
- Time spent in detailed history-taking and physical examination, even when results are normal, pays rich dividends in a sense of mastery and experience with the range of normal variations.

Introduction

A Note on Modern "Documentation"

At the outset, the student needs to recognize that this chapter concerns the traditional case record, which these days the student may see only when reviewing old charts. There is an increasing tendency for the medical record to be co-opted for many purposes other than patient care: to determine third-party payment (supporting or serving as the rationale for denying a claim); to perform institutional reviews aimed at "utilization review," "resource management," or "quality assurance"; or to serve as evidence in malpractice litigation or cases of alleged insurance fraud or other crimes such as the prescription of controlled substances "not in the course of a legitimate medical practice."

The needs and demands of third parties may so change the medical record that its usefulness in patient care may be greatly degraded (Orient, 1998). One private physician told this author that he essentially prepares two documents every time he writes a letter to a referring physician, one to comply with demands of the third party and one to communicate his analysis of the patient's case so that it may be understood by another physician.

An honest, accurate, and coherent medical record is essential for the practice of good medicine. Therefore, the student should learn how to prepare one, even though in many instances he may be required to accede to third-party demands. The importance of a complete, unaltered medical record is often emphasized as a defense against malpractice claims. It must be remembered, however, that evidence works both ways. Anything you write in the record can also be used against you—or against your patient, as for denying coverage, foreclosing employment opportunities, or indicting for a crime.

What is *not* written in the chart could also be grounds for criminal prosecution (*vide infra*).

If you need to make an addition or correction in the record, mark through an error with a single line and initial and date any change. The worst thing you can do if served with a lawsuit or notice of an audit or investigation is to try to "fix" the record.

Scrupulous honesty is, and always has been, a mark of a good physician or scientist. Combining this quality with discretion in recording is of increasing importance. This is especially true whenever records are converted into computerized format. Once data are in a networked computer, limiting dissemination or correcting errors may be virtually impossible.

Record-keeping offenses, including illegible handwriting, are increasingly being used as a pretext for disciplinary sanctions, including delicensure.

The Health Insurance Portability and Accountability Act of 1996 and Other Laws

Health Insurance Portability and Accountability Act of 1996 (HIPAA) has had a profound effect on the medical record. First, it turned any misstatement to any insurer into a federal crime. This includes errors in coding procedures such as not specifying the various levels of complexity of office visits. Charts may be seized by federal agencies in order to investigate physicians and facilities for billing improprieties. The notes for each visit are expected to include information to justify the procedure code.

Second, the HIPAA Privacy Rule created a large number of procedural requirements that "covered entities" are obliged to follow. A "covered entity" is a "provider" that files electronic claims or engages in certain other electronic transactions, largely related to payment. Patients now have the right to demand copies of most records, with some narrow exceptions such as psychotherapy notes, and to ask for revisions. The usual precautions about altering the record apply. Although access to records by caregivers may be impeded, a very large number of private and governmental entities have expanded access to information in the records. The student and "covered" physician will need to be aware of the procedures that apply to them. The prerevolutionary physician will want to learn about the "country doctor exception" for noncovered entities (U.S. Department of Justice, 2001).

Third, the transaction code sets rule of the HIPAA requires submission of insurance claims in a standard format. This may require

collection of data that have not been part of the traditional medical record (such as the patient's shoe size in a podiatrist's records). The ultimate objective of influential agencies and organizations is a fully electronic medical record, with its inevitable constraints on what must be, can be, or cannot be recorded. The effect of translating the medical record into numeric codes and back again will have interesting results, perhaps comparable to the translation of a poem from English into Chinese and back again.

Physicians will face some difficult ethical dilemmas, most clearly illustrated in 2004 by federal prosecutions of physicians related to the prescribing of controlled substances, especially opioid analgesics. At least two states have a "doctor shopping" law. The Florida statute,[1] brought to attention because of drug allegations against prominent radio talk-show host Rush Limbaugh (Schlafly and Gregoire, 2004), makes it a crime for a patient not to inform a physician of visits to other physicians in the previous 30 days if controlled substances were prescribed. Physicians who do not make adequate efforts to obtain information of this type could also face criminal conviction or delicensure.

Patient admissions of behavior such as using someone else's prescriptions create liabilities for both patient and physician. An Arizona physician (*U.S. v Jeri Hassman, M.D.*) pleaded guilty to four felony counts of being an accessory after the fact to patients' illegal possession. The facts were documented in her records, yet she had not breached patient confidentiality by calling the police to report the patients for having used medications prescribed for someone else. Although this author knows of no patients who have been indicted for such behavior, the admissions can be used to pressure patients into testifying against physicians.

Other items that might have legal repercussions include patients' discussions about the use of illegal substances by themselves or by family members; information about the possession of firearms in the event that this is or at some point becomes illegal; patients' (or their parents') refusal to comply with certain state mandates, for example, immunizations; and certain child-rearing or religious practices. This author is deliberately not including samples of patient questionnaires that contain such items as part of the social history, despite the recommendations of various professional societies. Patients who are concerned about misuse of the information—by hackers, blackmailers, hostile ex-spouses engaged in custody battles, or government agents—may refuse to answer these questions or may even change physicians. More likely, they will simply fail to answer honestly.

Pedagogy

When first seeing patients, it is hard to remember all the parts of the history and all the questions in the review of systems. Therefore, a well-tested outline is given here (although the student may wish to substitute a different one supplied by his school). After examining about 100 patients using this form, the student will know it by heart. At that time, it may be substituted with a shorter form.

The educational principle is that initially one is well advised to be complete (even if it means being labeled "OC" or obsessive–compulsive) and only later to use truncated approaches. This general principle of medicine applies to far more than just the case history. First of all, if one can perform, say a complete neurologic examination according to the outline, then at any future date, one can revert to this examination when confronted with a patient who has a neurologic problem and not be limited by the currently ubiquitous "grossly normal." Second, if one rigorously follows this outline, one incidentally gains a great deal of experience with the normal, enabling one to recognize variations of the normal and to pick up subtle abnormalities. Third, the use of this outline in conjunction with a differential diagnosis will quickly convince even the neophyte of the power of a thorough examination. Finally, as the repeated examination becomes faster and faster, the student gains a salubrious sense of mastery that must be experienced, literally, to be appreciated.

You will be richly rewarded for the time spent writing and rewriting your history, not only in your case presentations but also in the development of your skills in acquiring the information and formulating diagnostic hypotheses.

How Much Time Does the Examination Take?

When I was a junior medical student, it took 2 hours for me to obtain a complete history. A complete physical examination took another 2 hours. To record this information, to construct my differential diagnosis, and then to add the laboratory tests that we were supposed to do ourselves (routine and microscopic urinalysis, hemoglobin and hematocrit, white count and differential, and electrocardiogram) took another 2 hours, making a total of 6 hours. I should add that most of these patients had but one major diagnostic problem; nevertheless, this problem was often a diagnostic challenge and required the student to do considerable reading.

After three medicine rotations, we could perform and record a complete history and physical (without laboratory work) in the outpatient department in about 2 hours. At that time, I was once assigned a woman who was deaf and dumb. Because the entire history, questions and answers, had to be written longhand, it took me 4 hours. The 4 hours were well spent because, after visits to many doctors, the patient's diagnosis was finally made. She suffered from what would now be called *neurocirculatory asthenia*. Previously, she had received only incorrect diagnoses carrying an ominous prognosis. Her secondary neurosis was completely reversed after I saw her, one of my first solo transference cures.

By the time I was an intern, I could perform and record a good two-page history and physical in 1 hour, only occasionally missing nystagmus or failing to elicit muscular fasciculations. At the time of my oral examination in internal medicine, 7 years after graduation, I could do a complete history and physical on two patients in 1½ hours.

The student should not be discouraged by what at first seems an overwhelming task. Attention to detail at the beginning is time consuming but necessary and richly rewarding in the long run. For faculty to say, "we can't teach this in our curriculum because there is not enough time" is analogous to a surgeon declining to insert an artificial heart valve because it would take more than 2 hours.

[1] Florida Statute 893:13(7)(a)(8) makes it a crime "to withhold information from a practitioner from whom the person seeks to obtain a controlled substance or a prescription for a controlled substance that the person making the request has received a controlled substance or a prescription for a controlled substance of like therapeutic use from another practitioner within the previous 30 days."

Model Outline of Gerry Rodnan, MD

The following is an abridgment and revision of the outline given to our class at the University of Pittsburgh in the fall of 1958 by our course master, Dr Gerry Rodnan.[2]

I used it with good results for 10 years, after which I became a consultant and was allowed to improvise.

A. *Identification*
   Name, age, sex, marital status, color, occupation, religion, birthplace (state or country), referring physician and/or agency, date of examination (including year).
B. *Informant and Reliability*
C. *Chief Complaint*
D. *Present Illness*
   The present illness is not simply a complete but disorganized catalog of statements and facts. The organization of the history is based on two principles:
   1. The major problem from which the patient is suffering must be dissected free of other unrelated information.
   2. The progression of the major disease from its inception must be made clear, culminating in an evaluation of the current effects of the illness on the patient's life.
E. *Past History*
   1. *General health:* Give the patient's estimate of his health in general. Body weight: present, maximum, minimum, recent change. Any significant facts from previous physical examinations (military, school, insurance, employment, etc.).
   2. *Serious illnesses:* Record any infectious disease or prolonged illness.
   3. *Injuries:* Broken bones, lacerations, or other injuries.
   4. *Operations:* Date, diagnosis, postoperative course, biopsy reports.
   5. *Admission to other hospitals:* Record chronologically, giving the name of the hospital and physician and the source of the information. List admission and discharge dates; give a brief summary of presenting symptoms and significant physical or laboratory findings if known, diagnoses, and therapy.
   6. *Past admissions to this hospital and outpatient department:* If the patient has been seen frequently in the outpatient department, each visit does not need to be summarized, but appropriate resumés of time intervals or change in symptoms must be recorded. Such hospital admissions and clinic visits should be summarized chronologically in the following form:
      Number of admission (first, second, etc.):
      Service (medical, ENT, surgical, etc.):
      Date of admission:
      Date of discharge:
      Operations:
      Summary: This summary should be sufficiently detailed to contain all pertinent symptoms, physical findings, laboratory results, medications, and course in the hospital.
   7. *Current medications*
F. *Review of Systems*
   The chief symptoms referable to each system are reviewed. Information that belongs with the present illness will frequently be obtained and should be recorded there. Repetitions are to be avoided by referring to preceding sections that contain the same information.
   1. *Skin:* Abnormal pigmentation, sweating pattern, bleeding, bruising, eruptions, itching.
   2. *Lymph nodes:* Enlargement, pain, sinuses, drainage.
   3. *Head:* Headache, injury, fainting, seizures.
   4. *Eyes:* Vision, inflammation, pain, diplopia, scotomata, exophthalmos, glaucoma.
   5. *Ears:* Hearing, pain, discharge, tinnitus, vertigo.
   6. *Nose and throat:* Abnormal odors, discharge, bleeding, obstruction, pain, sore throat, change in voice, hoarseness, goiter.
   7. *Breasts:* Masses, pain, discharge.
   8. *Cardiovascular, respiratory:* General exercise tolerance, dyspnea, cough, sputum (amount, description), wheezing, hemoptysis, chest pain, fever, night sweats, orthopnea, edema, cyanosis, hypertension, palpitations, history of heart murmur, treatment with cardiovascular drugs (such as digoxin, diuretics, or nitroglycerin), intermittent claudication, leg ulcers.
   9. *Gastrointestinal:* Appetite, condition of teeth and gums, sore tongue, dysphagia, nausea, vomiting, hematemesis, constipation, diarrhea, unusual stool color or consistency, abdominal pain, jaundice, results of gastrointestinal X-rays, food intolerance, rectal bleeding.
   10. *Endocrine:* Growth, body configuration, symptoms of increased or decreased metabolism. Polyphagia, polydipsia, polyuria, glycosuria. Sexual development, impotence, sterility, menstrual history (age at onset, cycle, duration, amount, amenorrhea, menorrhagia, metrorrhagia, dysmenorrhea, date of last period, premenstrual edema and tension, number of pregnancies, induced or spontaneous abortions, stillbirths, live births, obstetric complications, age of menopause, hot flashes, postmenopausal bleeding).
   11. *Allergic and immunologic:* Urticaria; angioneurotic edema; hay fever; asthma; eczema; sensitivity to drugs, foods, pollens, dander. Immunizations and skin tests.
   12. *Musculoskeletal:* Pain, swelling, stiffness, limitation of motion of joints. Fractures, serious sprains.

[2] Gerry P. Rodnan, MD, was a professor of medicine and a rheumatologist at the University of Pittsburgh. He is known for Rodnan's Law (1959): "Corticosteroids will do anything if you give enough of them." Rodnan's Rule of Urine was stated in 1971: "In a contemporary teaching hospital, it takes 72 hours to collect a 24-hour urine specimen." Rodnan's Aphorism states: "All the great diagnosticians are not at the university center. And all the bad ones are not in the community hospitals."

Rodnan was also the inventor of the "professorial dozen." He noted that whenever a full professor was asked how many cases he had seen of some unusual entity, the professor would say, "Oh, about a dozen." Rodnan suggested that the dozen was generated in the following manner: The junior medical student saw a case at Grand Rounds. (Historically, patients were presented at Grand Rounds; today, the activity that goes by that name bears no resemblance to the patient-oriented sessions of bygone days.) He referred to that case in the senior year, thus making it two. By the time he was an intern, the case had multiplied to three. As a junior assistant resident, the very same case had become four, and so forth, as he rose through the ranks. By the time he was a professor, it was a professorial dozen.

13. *Neuropsychiatric:* Headache, convulsions, loss of consciousness, paralysis, weakness, atrophy, spasticity, tremor, involuntary movements, gait, incoordination, pain, change in sensation, paresthesias, incontinence, sweating pattern. Predominant mood; anxiety; phobias; sleep pattern; memory; judgment; thought content (delusions, hallucinations); history of psychiatric care, sexual adjustment, attitudes toward friends, associates, family, disease.

G. *Family History*

Record the age and health (or death and cause of death where appropriate) of parents, siblings, and children. Investigate the familial incidence of obesity, diabetes, cardiovascular and renal disease, cancer, neuropsychiatric disease, allergy, blood dyscrasias, arthritis, glaucoma, and infectious diseases such as tuberculosis. Many diseases are clearly heritable; many others have an important hereditary "tendency." A careful family history may suggest a good diagnostic possibility or may provide support for a tentative diagnosis.

H. *Social History*

Record the nativity, occupation, marital adjustment, and especially the patient's emotional relationship with the parents throughout his life. The patient's birthplace, residences, and education are important. The marital history includes age, health, occupation, educational level of the marital partner, number of children, and the marital adjustment. Describe the "extended family group." Also, who lives with the patient at home (not necessarily the same as the "extended family")? Learn exactly what the patient does in his occupation with particular reference to the degree of emotional tension or health hazard. What provisions are there for disability compensation and other marginal benefits? Are there debts or economic problems that will influence convalescence? How much does the patient participate in the civic, social, religious, and political activities of his particular economic and social group? How do his opinions or practices differ from those of the group (this presupposes previous knowledge or inquiry into the group opinion)? What are the medical opinions of the group? Find out in detail how the patient spends his day, what his hobbies are, how much he relaxes, how much he sleeps, and how much physical activity there is. Learn the patient's dietary habits; this usually requires specific inquiries regarding each meal. Are tobacco, alcohol, narcotics, or other drugs used? If so, to what extent?

I. *Physical Examination*

1. *Vital signs:* Temperature, pulse, respiration, blood pressure (both arms and one leg, record position), height, weight.
2. *General appearance:* Development, nutrition, mental status, apparent age, race, sex, position in bed, comfort, attitude toward examination, degree of illness (acute or chronic), obvious abnormalities. A short statement embodying these features should always introduce the physical examination.
3. *Integument:* Skin: color (jaundice, pallor, cyanosis, pigmentation, erythema), temperature, texture, moisture, eruptions, petechia, telangiectasia, nodules, scars. Nails: color, shape, texture, subungal hemorrhages, paronychia. Hair: distribution, texture, quantity, color.
4. *Lymph nodes:* Size, consistency, tenderness, mobility, sinuses; description of cervical, occipital, supraclavicular, axillary, epitrochlear, inguinal, and femoral nodes.
5. *Skull:* Size, contour, tenderness, bruit.
6. *Eyes:* Vision, protuberance; extraocular movements, nystagmus, strabismus; lids, sclerae, conjunctivae, cornea, ocular tension; pupillary size, equality, regularity, reactions to light and accommodation; ophthalmoscopic examination of lens, vitreous, discs, retina (scars, pigmentation, hemorrhages, exudates, macula), vessels.
7. *Ears:* Hearing, air and bone conduction; pinnae, external canal; drum, perforation, discharge.
8. *Nose:* Mucous membranes, obstruction, polyps, discharge, septum, sinus tenderness and transillumination.
9. *Mouth:* Color and lesions of lips; odor of breath; size, position, tremor, papillae, color, coating of tongue; number, condition, and alignment of teeth; pigmentation, ulceration, bleeding, infection of gums; eruptions or pigmentation of buccal mucosa.
10. *Throat:* Position of uvula; color, exudates, lymphoid tissue in posterior pharynx; tumors or ulceration; tonsils; voice, vocal cords.
11. *Neck:* Contour, mobility; tenderness, masses; thyroid size, consistency, bruit; tracheal position or tug; salivary glands.
12. *Breasts:* Size, contour, tenderness, masses, discharge, scars, nipples.
13. *Thorax and lungs:* Inspection of thoracic contour and respiratory motion with special attention to the detection of diffuse obstructive or restrictive impairment of respiratory mechanics; palpation for tenderness, fremitus, rubs, wheezes; percussion, including descent of diaphragms; auscultation of breath sounds, spoken and whispered voice, adventitious sounds (rales, friction rubs).
14. *Cardiovascular:* Heart: inspect apical impulse, other pulsations. Palpate apical impulse, thrills, shocks. Percuss heart size, contour (describe in relation to the midclavicular line). Auscult rhythm, quality, and intensity of heart sounds including third and fourth sounds or gallops if present; murmurs (location, timing, intensity, character, transmission; relationship to position, respiration, or alterations in cardiac rhythm); friction rubs. Check for apical–radial pulse deficit (see Chapter 6). Peripheral vascular system: thickening or tortuosity of peripheral arterial walls; abnormal or absent arterial pulses. Character and equality of carotid, brachial, radial, femoral, popliteal, dorsalis pedis (DP), and posterior tibial (PT) pulses. Arterial bruits. Venous distention, pulsation, tenderness, or inflammation. Abnormal venous pattern over chest and abdomen.
15. *Abdomen:* Inspection: contour, abnormal venous structures, peristalsis, scars. Palpation: tenderness (local or rebound), spasm, masses, organs (liver, gallbladder, spleen, kidneys, uterus, bladder), heaviness of flanks, fluid wave, hernias. Percussion: organs, masses, shifting dullness. Auscultation: peristalsis, bruit, succussion splash.
16. *Genitalia:* Male: development, scars, discharge, tenderness or masses of epididymides and testes. Female: perineum, labia, vagina, cervix, size and position of uterus and adnexae; examine for masses, tenderness, discharge, ulceration.
17. *Rectal:* Hemorrhoids, fissure, fistula, sphincter tone; prostate (size, contour, consistency), seminal vesicles; consistency and appearance of feces.

18. *Musculoskeletal:* Spine: contour, motion, tenderness. Muscles: tremor, atrophy, fasciculation. Joints: deformities, crepitation, range of motion, swelling, tenderness, heat, redness. Extremities: clubbing, edema.
19. *Mental status:* Behavior: appearance, facial expression, activity. Speech: rate, quality, quantity. Mood: depression, euphoria, resentment, fear, anxiety, lability. Content of thought: obsessions, delusions, ideas of persecution. Sensory deceptions: illusions, hallucinations. Sensorium: orientation (time, place, person), state of consciousness, memory (recent and remote). Intellectual endowment (not synonymous with education). Judgment and insight.
20. *Neurologic:* Every complete physical examination should include a brief survey of the cranial nerves, motor and sensory systems, and reflexes. If there is any indication from the history or physical examination that the patient has a neurologic defect or if the disease that he is suspected of having is frequently associated with neurologic complications, a detailed neurologic examination according to the following outline should be conducted and recorded:

Cranial Nerves

I. Recognition of odors.
II. Visual acuity and fields, optic discs.
III, IV, VI. Pupillary size and reactions, eyelid droop, extraocular movements, lid lag.
V. Sensations of face and tongue, corneal reflexes, chewing muscles.
VII. Facial muscles; taste of anterior two thirds of the tongue.
VIII. Hearing (bone and air conduction, Weber test), nystagmus.
IX. Sensation of hard and soft palate, gag reflex; taste of posterior one third of tongue.
X. Weakness of soft palate, deviation of uvula, difficulty in phonation, vocal cord paralysis, rapid pulse (bilateral lesion).
XI. Sternocleidomastoid and trapezius functions.
XII. Tongue muscles, protrusion and deviation.

Skilled acts: Aphasia, apraxia, agnosia, astereognosis.

Handedness: Record whether the patient is right- or left-handed.

Meningeal signs: Stiff neck, Kernig, Brudzinski.

Posture, gait, and abnormal movements: Standing and reclining posture; circumduction, propulsion, ataxia; tremors, tics, athetosis, chorea, localized muscle spasm.

Coordination: Finger to nose, heel to knee, adiadochokinesia, rebound, past-pointing, Romberg.

Motor system: Muscle strength, tone, volume, contractures.

Reflexes: Biceps, triceps, radial, knee (clonus), ankle (clonus), abnormal, cremasteric, plantar response.

Sensation: Pain (superficial and deep), temperature, touch, position, vibration.

Autonomic: Sphincter tone, sweating, vasomotor changes, trophic disturbances.

J. *Differential Diagnosis*

Comments on Historic Information

Reliability

Early in the case record, the examiner is asked to comment on the reliability of the informant. As discussed in Chapter 2, no patient should ever be described as a "poor historian." If the interviewer has noticed that the patient has trouble remembering events, if the physician has performed the cognitive portion of the mental status examination, as described in Chapter 2, and if, in fact, the patient is cognitively impaired, then it is fair to conclude that the patient has either mental retardation or an acute or chronic dementia. (Unfortunately, the cognitive portion of the mental status examination is performed by asking questions without touching or inspecting the patient's body. Therefore, some tyros omit this section of the neurologic examination from their physical examination, believing it to be part of the interview. Whatever the reason, this extremely important part of the physical examination is the part most frequently missing from the record.)

Examples

"Reliability: The patient was a pleasant man who attempted to cooperate but who was disoriented to time (missing the day and month, but not the year)."

"Reliability: The patient is disoriented to time but not to person or place. Most of the history of the present illness (HPI) was obtained from his landlady. History of prior illness comes from our inpatient records, but the outpatient records were not available at the time of admission."

Informant or Source

In the case of the comatose patient, the informant will be a person other than the patient. The informant's name and relationship to the patient, as well as the duration and frequency of contact with the patient, should be indicated in the upper right-hand corner of the first page of the case report:

"The informant is the patient's consort, who has lived with her for 2 years."

"The informant is the patient's son, who had not seen the patient for 4 years up until the day of admission."

"The informant is a policeman who discovered the patient in the hallway."

At times, the old record may be the only source material for the history. In this instance, the informant statement might read: "Patient brought in by the police, who know nothing about him. The only historic material available is from our old inpatient records."

The reliability of the old records is not to be taken on faith. It is frequently stated that "if it wasn't documented, it wasn't done (in the view of lawyers and peer reviewers)." This is an assumption, not a universal truth. In fact, in a study in which nurse practitioners were observed by a research assistant who coded all activities, historic findings (such as medications, the location of pain, and exacerbating and relieving factors) were written down only one third as often as they were elicited (Orient et al., 1983). Of course, if it was not documented, you have no way of knowing whether it was done.

The inverse of the statement is also not necessarily true: That something was documented does not prove that it was done (or done

carefully and competently). In the same study, the act of percussing the spine was observed to occur in only 35% of the cases in which the "results" of this examination were recorded on the patient's chart. The comparative reliability of checklists and written notes has not been investigated, to my knowledge. On the basis of introspection, I tends to believe an examiner actually listened to the heart if he writes "no murmur or gallop," even in abbreviated form, but places little confidence in a checkmark on a checklist. The latter might just mean "didn't notice it," rather than "looked for it carefully and didn't find it." In other words, the proportion of false negatives is thought to be higher for items recorded on checklists. (This author knows of at least one physician who admits that on a checklist, "WNL" means "we never looked" rather than "within normal limits.")

General Considerations on Authoring the Medical Record

The Physician's Responsibility

The author of a medical record creates a legacy that may follow the patient for the rest of his life. The record is a literary work and a tool that is supposed to benefit the patient. Creating a good record is a difficult and time-consuming task. Physicians in primary care specialties can easily spend 10% of their professional life authoring patient records. Case histories are created, not taken. It is important to be complete, accurate, legible, and concise and to organize the story in a logical manner. It is also essential to present the patient as a person worthy of respect.

Dehumanizing or Humanizing the Patient: An Example

A second-year medical student approached a patient with dread as she read the note of the outgoing fourth-year student: "This is a difficult, noncompliant 47-year-old alcoholic who comes to the clinic repeatedly for multiple somatic complaints." The student set a goal for herself of finding out who the person, Ms Green, really was. She allowed the patient to speak without interruption. She discovered that several preventive interventions were overdue and negotiated a plan. As Ms Green left, she told the student that no one else had ever really listened to her.

After the visit, the student added several new items to the problem list: illiteracy, loneliness, grief, and poverty. She also added a narrative description to help keep future students and physicians from being "poisoned" by the record (Chop, 1997):

> Margaret Green is a pleasant 47-year-old woman. She was orphaned as a baby and raised in a series of foster homes. She was physically and mentally abused in many of the homes, until finally, at the age of 13, a woman took her in who loved her, cared for her, and adopted her. As she was hard of hearing, she did poorly in school, finally dropping out at age 16 because she could not keep up and because so many children made fun of her. For the next 20 years, she was employed cleaning buildings, but after she turned 40, her adopted mother suddenly died. Her health deteriorated, and she quit working. . . .

Patient Photographs

Many private physicians take a photograph of the patient to place in the record. Besides serving as a useful patient identifier, it adds a human dimension to the record. On occasion, it may be of later diagnostic value (see Chapter 5).

Abbreviations

Although some schoolmarms have attempted to drive abbreviations out of the medical record, human nature remains unchanged. Some institutions even have standing committees to designate certain abbreviations as acceptable, but their pronouncements are heeded about as well as those of the schoolmarms who preceded them. Unless your preceptor has strong opinions, I would suggest the following: use abbreviations only when the context renders the abbreviation totally unambiguous.

Example of an acceptable abbreviation: "The patient was treated with IV MS in 2-mg doses to a total of 12 mg in the first hour." Here, MS obviously means morphine sulfate.

Example of an unacceptable abbreviation: "In 1986, he was told that he had a mild case of MS." In this context, the abbreviation is ambiguous, as it could mean either mitral stenosis or multiple sclerosis.

Chief Complaint

The chief complaint (or chief concern) is discovered in the course of the interview (see above) and is not necessarily the complaint that was written on the emergency room sheet by the nurse. Nor is it necessarily the first problem that the patient mentions. Some discussion may be required to elicit the problem that is really bothering the patient most.

The chief complaint is singular. On very rare occasions, one may wish to list two separate chief complaints. In such situations, one is also obliged to produce two separate histories of present illnesses, one to match each of the chief complaints. An exception to this rule is the presence of two symptoms that invariably accompany each other, such as polyuria and polydipsia or nausea and vomiting.

Examples of two separate chief complaints:

1. "My arthritis has come back" (1-month duration).
2. "I have been drinking an awful lot of water and getting up five times a night to pee" (7-month duration).

In the latter example, the examiner had discovered, on review of systems, a second pair of problems that suggested one of the types of diabetes, with no apparent relationship to the patient's rheumatic complaints. Instead of making two chief complaints, the physician could have made the new, more exciting endocrine problem the chief complaint and placed an asterisk beside the rheumatic problem in the past medical history section. (An asterisk beside an entry in the case record means that the problem will be dealt with in the "impressions" or the summary section or, in the case of the experienced physician, on the order sheet.)

The phrase "rule out" should never be used in a chief complaint, as in "the patient was admitted to rule out myocardial infarction." First, this type of statement does not give the patient's own description of his illness. Second, it puts the historian (the physician) in a logical dilemma. If he diagnoses a myocardial infarction, he has succeeded in making a diagnosis by failing at the appointed task of ruling it out. On the other hand, if he succeeds in that task, he has

failed to make a diagnosis. Yet the patient still has chest pain or some other symptom. It is hardly desirable to send the patient home with nothing more than the negative statement, "You didn't have a heart attack."

Sometimes patients are admitted to the hospital by their physicians, and they do not know why. Sometimes they think they know and are mistaken; this can lead to interpersonal difficulties later in the hospitalization. It is a good idea to ask such patients, "Why do you think Dr Jones sent you to the hospital?" A good follow-up question is, "Did he ever actually say that?"

Even patients who are in the hospital because of a doctor's request deserve to have a chief complaint, which should be stated in specific terms that indicate the level of certainty. For example: "The patient is admitted at the request of the cardiology service for elective coronary angiography." Such a statement of high certitude would be based either on a conversation with one of the cardiologists or on a letter brought by the patient. An example of a still useful statement with a lesser degree of specificity and certitude is this: "Her local physician referred her to this institution to have her 'gland problem' evaluated by Dr Smith." If you have not spoken to any of the referring physicians, do not assume that the "patient is here to get her digoxin and Lasix adjusted" on the basis of her flagrant signs of congestive heart failure. In reality, the patient might have high-output heart failure due to masked thyrotoxicosis and actually might have been referred to the endocrinology service for definitive therapy.

The worst type of chief complaint is one that uses contemporary medical jargon without giving either the problem or the level of uncertainty. For instance, one medical resident's note said, "Patient admitted for a tune-up." To say that this description would be more appropriate to the care of an automobile than of a human being would be unfair to automobile mechanics, who usually ask the customer what problem he has noticed.

The "Problem-Oriented" Medical Record

In the Weed problem-oriented medical record (POMR), it is usual to have multiple "problems" derived from patient complaints, each of which is supposed to have its own SOAP (subjective, objective, assessment, plan) in the record, titled and indexed to a specific problem, although this requirement is usually honored by omission. I have found only one feature to be helpful (the problem list), and that could be harmful to the patient if sent to a third party by mistake. I did not expect the system to outlast the first edition of this book. Although it has been more persistent than most fads, the POMR will not be discussed in detail here. Weed's terms have no obvious advantage over the traditional "history," "physical," "laboratory," "impression," and "plan." Weed's use of the terms "subjective" and "objective" can be misleading (see "definitions" in Chapter 1). In fact, they may give the impression that the patient's observations are necessarily less valuable than the physician's and that the physician's are somehow untainted by bias, prejudice, irrationality—or humanity. Because the Weed record may distort or restrict the depiction of reality, some have called for its rejection (Donnelly and Brauner, 1992).

Even proponents of the Weed system have difficulty balkanizing patients in a consistent manner because problems overlap and interact. Attempts to do so only exacerbate the difficulties in caring for real human beings, who experience multidimensional illnesses. The medical record, like good medicine, should be *patient* oriented, in my opinion.

Proponents of the Weed system, or, more recently, the electronic medical record, appear to regard the medical record as a storage-and-retrieval device. To the prerevolutionary physician, however, the course of illness is an unfolding story in which various physicians and other caregivers participate, recording their observations, impressions, and interventions. Because of the inherent nature of the practice of medicine as human interactions, some will "not be surprised to see the narrative history and physical examination ultimately replace the current, disappointing problem-oriented medical record" (Cassell, 1997).

History of the Present Illness

Chronology

When composing the HPI, one wishes to tell the story in a chronologic fashion. To avoid confusing the reader or the listener, one of two available chronologic systems should be chosen and used consistently. In the first system, all events are related to the time of admission, for example:

"The history of the present illness began approximately 10 years prior to admission (PTA)."

"However, 4 years prior to admission…."

"Two months prior to admission…."

"Three days prior to admission…."

"A fever began 10 hours prior to admission, continuing up to 2 hours prior to admission, when…."

"Forty-five minutes prior to admission…."

"…15 minutes prior to admission, when his wife decided to bring him to the emergency room."

The second system uses calendar dates. With this method, the HPI might proceed as follows:

"…began in 1959."

"…recurred in the fall of 1968 and continued into the next summer."

"In 1972, the patient first noticed…."

"In February of 1980…."

"In March of 1981…."

"June 6, 1981, the patient first noticed…."

"June 16, the patient was admitted to the emergency room, kept for 6 hours and discharged. At that time,…."

"June 24, 1981, at 12 noon…."

"Around 4:00 p.m., the patient noticed that…."

"At 6:15 p.m., his wife insisted on bringing him to the emergency room. When he arrived at 6:45 p.m., he had no palpable pulses in his legs…."

The first system has the advantage for the listener or the reader of being easier to follow. The calendar system has the advantage of placing the patient's history in its broader historical context, in terms of what diagnoses and treatments were available in that epoch, and may be more useful for longer histories. Also, the person who

reviews the record several years later will not have to translate the times into a different reference system.

Pertinent Positives and Negatives

After the chronologic account of the present illness, there is sometimes an extra paragraph involving pertinent negative and/or positive facts that bear on the HPI. The emphasis on the word "pertinent" warns that this section is not to be an assortment of potentially interesting but possibly irrelevant facts that you could not build into the HPI. (Such an assortment would only detract from the review of systems and confuse the auditor or reader who might have been just on the verge of arriving at a diagnosis.) In fact, most well-organized histories do not need a final statement of additional pertinent positives and negatives.

Some epidemiologic cardiologists enjoy the recitation of their favorite coronary risk factors. Some pulmonologists wish the presenter to produce at this point the date of the last chest film and a summary of its findings. Some infectious disease specialists want the presenter to give the results of the cultures drawn at the referring hospital (or the lack of cultures or unavailability of results). If you have tried but really cannot think of any pertinent positives, do not worry about it. They are probably unnecessary in that particular case. Recently, the patient's drug regimen seems to have migrated to the pertinent positives section, where it does not belong. See the section on past medical history below.

Pertinent negatives are absent factors, which, had they been present, would have suggested another diagnosis. For example, a normal recent chest film might cause the presenter to doubt the diagnosis of tuberculosis. "The patient has never smoked" suggests the presenter's belief that the patient probably does not have bronchogenic carcinoma. "There has been no weight loss" is probably the most common pertinent negative.

Pertinent positives and negatives of the type given above are global and almost matters of taste. However, more discrete pertinent positives and negatives are in common use. An example of a discrete pertinent positive is "Four other persons attending the wedding were said to have been afflicted with a similar illness. Food served at the wedding dinner is currently being analyzed for staphylotoxin A by the State Laboratories." (Of course, this information might just as well be incorporated into the narrative of the present illness, rather than be segregated as a pertinent positive.)

Rule: *Use pertinent positives and negatives only when they are relevant to items in your differential diagnosis.*

Information Obtained from Chart Review

In the better contemporary courses in clinical examination, the sophomore students are prohibited from reading the patient's chart until they have produced their own case record. Although pedagogically valuable, this prohibition does impair the quality of the historic information available. In the usual clinical situation, one is obliged to read all the old case records and to obtain copies of the same from other hospitals as soon as humanly possible. In all instances, one must evaluate the information thus obtained in a critical manner, as explained in Chapter 3, and indicate its level of certainty. (Also see the "Miracle of the Right Eye," a "Buccolingual Pedagogic Note" in Chapter 10.) The fact that the record may be stored in a computer does not enhance its accuracy.

Advice to the Sophomore. Chart review is a skill in itself. The practice of chart review is also an effective way of learning how to keep good records. A thick chart will generally contain several notes that are particularly helpful. Read them carefully, determine what makes them especially helpful, and try to emulate them (Chop, 1997).

Including Diagnoses in the Case Report

You may include the previous diagnostic conclusions of other physicians in the case report, with the caveats given in Chapter 3. However, you may not include your own diagnostic conclusions in the body of the history or physical report, no matter how high the level of certainty may be. The proper place to enter your conclusion is in the "impression" or on the list of differential diagnoses. To use it in the history would be circular reasoning. Thus, the tradition of the case record may be seen as an implied attempt to invoke the rules of logic at a clinical level.

Advice to the Sophomore. Ordinarily, we attempt to perpetrate the fiction that the sophomore student saw the patient at the time and date of admission. This gives the student the opportunity to compare his case write-up with that of a more experienced person who saw the patient at the time of admission. However, the patients selected for student examination have generally been in the hospital for some time and in the course of a good interview will mention to the student potentially significant events that have occurred during hospitalization. There are no hard-and-fast rules, but the general principle of intellectual honesty applies: any such postadmission information used in reaching your diagnostic conclusions or ordering your differential diagnoses should be mentioned, even if the patient volunteered it. For the neophyte, such unsolicited extra data could be entered into the HPI under a special section of unsolicited pertinent information (pertinent positives or negatives).

Expressions to Avoid

Two statements, rapidly becoming ubiquitous, that should never appear in a case write-up are "the patient stated" and "the patient denied." The former is a wasteful redundancy. Unless some other informant is being used, the entire history can usually be assumed to be stated by the patient. The second phrase is used in place of "there was no…" but does not mean the same thing. For a patient to deny a statement, it must be true, and the patient must have some important unspoken reason for saying it is false. Of course the term "denial" also implies that the doctor knows what is true and what is not in which case it is unclear why he is asking the patient questions to which he already knows the answers. Worse, the term is better suited to an interrogation than to an interview and hints at an adversarial relationship between the doctor and the patient (see Chapter 2).

If the patient says he did not have a seizure, whereas in fact he had one but cannot remember it, his statement is not really a denial. If the doctor, whether at the bedside or in the case record (which is more and more frequently being read by patients), characterizes something told to him in confidence as something that was "denied," imagine what the patient might think about that term were he to read the record. The implication is that the patient was lying.

Past Medical History

As a general guide to what goes in the past medical history, recall that this section is concerned with diseases and illnesses, whereas the review of systems is about symptoms.

Immunizations

The immunization record should be kept in a section of the chart where it is available for updating as the patient receives new immunizations. The date, dose, and source of the immunization should be listed for each (e.g., "Influenza: 1979, Cutter Labs split virus, triple vaccine, lot number ___, 0.5 mL, right deltoid"). For previous immunizations, one needs to indicate only their presence or absence, although a date is desirable, especially for tetanus toxoid. For children, precise dates are required, as the time of the vaccine may turn out to be important. For example, the first available measles immunizations had to be repeated if the vaccine was given at an age less than 15 months or before 1967 (when attenuated live virus vaccine replaced the inactivated type). For patients who engage in foreign travel, one should also indicate their status of immunization against yellow fever and cholera (e.g., "yellow fever +, cholera +, 1969 prior to Peace Corps trip"). For patients with special risk factors, particular attention should be paid to their immune status against rubella (women of childbearing age), pneumococcus (patients who have undergone splenectomy), hepatitis B (persons frequently exposed to this virus), and so on.

If you are having office forms printed up, be sure to leave sufficient space, as new vaccines are being introduced with some regularity.

New state or federal laws requiring submission of information on immunizations to government agencies in a specified computer format are beyond the scope of this book. You need to pay special attention to official updates on recommendations, requirements, and available exemptions of immunizations, especially if you are seeing children.

Concern about the thimerosal (ethylmercury) content of vaccines, especially for children who have a neurodevelopment disorder such as autism, shows the importance of recording the exact preparation that was received. From this information plus old editions of the *Physician's Desk Reference*, it should be possible to determine the cumulative dose of thimerosal. The ethylmercury content of vaccines in the recommended schedule received between birth and 6 months was 50 μg in 1950, 75 μg in 1970, and 187.5 μg in 1992 (Cave, 2004). A statement that a product is "preservative free" does not necessarily mean that it is thimerosal free, as thimerosal may be an integral part of the production process, not an additive intended to serve as a preservative (WHO, 2003).

The mother's vaccine history is pertinent in prenatal mercury exposure. The influenza vaccine, for example, contains thimerosal, as did Rho(D) immune globulin (RhoGAM) until 2002.

Hospitalizations

In recording hospitalizations within the past medical history, it is important that one obtains the dates, location, and reason for admission. A wise physician has his office nurse prepare release forms that the patient should sign before leaving the office the first time. For hospitals outside the city, it may be necessary to obtain addresses and postal (ZIP) codes. This "administrative" information about how to obtain the old records is valuable and often difficult to acquire. Therefore, it should be prominently placed in the medical record. Dr John Bass of Alabama stated that the most frequent and important service provided by his Pulmonary Division was not bronchoscopy but the retrieval and review of the patients' old records.

Old radiographic reports may be very useful but not as useful as the films themselves. Much cost and anxiety may be avoided if an old film shows, for example, that a pulmonary nodule has been present for years. Most institutions have a policy of destroying films after a certain period. Patients may wish to retain a copy of important films in their own possession.

Drugs

The patient's medications should be listed in the past medical history, unless there was a good reason for mentioning a specific drug in the HPI (e.g., digoxin in a patient with arrhythmia). (Include only the relevant drugs in the HPI. If a patient is admitted for a cardiac complaint, the allopurinol for gout, the benzodiazepine for insomnia, and the estrogen for menopause all probably belong in the past medical history.)

Social History

The student should refer to Chapter 3 and the outline above for the information that should be included in a complete social history. Psychosocial data may be included here or in the psychologic portion of the mental status examination, as you choose; however, you should be consistent. As a minimum, I consider it essential to have some notation about what the patient's most traumatic prior experience was and how he reacted to it.

State laws may have special requirements for certain conditions, such as infections with human immunodeficiency virus. Pertinent information may have to be segregated to prevent inadvertent disclosures when only standard informed consent has been received. Information relating to substance abuse or psychiatric treatment may also be specially protected.

Review of Systems

For recording the review of systems, it is particularly helpful to have a printed form containing the questions that you usually ask. This author finds a form especially useful with patients who do not speak English well (see Appendix 4.2 for a Spanish–English form).

A diagnosis that can sometimes be made from taking the review of systems is a form of hysteria called *Briquet syndrome* (see the section on the mental status examination in Chapter 26). This diagnosis is based on finding 25 different symptoms in 9 of 10 symptom groups, which had their onset before midlife and have no known medical explanation. This is a rather stable entity afflicting about 1% of the female population, so it is rather important that one be able to recognize it.

If a patient has had many hospitalizations or illnesses, it is likely that much of the review of systems will have been "prerecorded." It is legitimate to refer to available portions of the old chart, including

previous accounts of what was then the "present illness" but is now "past history." If one elects not to replicate the entire review, one should at least update it by doing an interim review of systems to see what formerly negative findings may have become positive. The rule is to save space and avoid redundancy but to be sure that all the information is timely and present somewhere in the record.

Physical Examination

The student who is reading this work in sequence, without having performed any portion of the physical examination, would do well to skip through the pages of this chapter having to do with recording the physical examination.

However, do not forget to come back to this section as you begin to perform physical examinations. By the time you are handing in written case records to your preceptor, you should have read this chapter at least once. To get the most out of it, you will probably find it necessary to work through it twice during your first year of doing case records: before and after studying the chapters on the various parts of the examination. Do not be discouraged if it seems a bit overwhelming at first.

This section presents "a method." If your preceptor or institution has strong feelings about some point, remember that, as in baseball, local ground rules are very important.

Vital Signs

Blood Pressure

The blood pressure notation should give the systolic pressure, the point at which the Korotkoff sounds become muffled, and the point at which they disappear as follows: 140/92/85. Often, the muffling cannot be detected, in which case one can record: 140/88.

One should state the extremity and the position in which the pressure was determined, for example, LUE (left upper extremity), LA (left arm), and RL (right leg). Lower extremity blood pressures will always be taken with the patient recumbent. However, for upper extremity blood pressures, one should say "recumbent," "sitting," or "standing," or draw stick figures. For recumbent as opposed to erect, two arrows would suffice: LA→ 140/80, ↑ 90/50.

In some unstable patients, and others, it will not be possible to determine the blood pressure by auscultation. In that case, one should determine the systolic pressure by palpation. (There is a technique for determining diastolic pressure by palpation, but it usually does not work in unstable patients; see Chapter 6.) Record such a pressure thus: BP LA recumbent inaudible, 90/? by palpation (*not* "90/palp"). It may be advisable to add the units mm Hg because there is an increasing tendency to express the pressure in kilopascals, millibars, newtons per meter square, and other exotic units. Past workers have also published pressures expressed in cm Hg.

Pulsus Paradoxus

Pulsus paradoxus refers to a decrease in systolic blood pressure with inspiration. As is pointed out in Chapter 6, some inspiratory decrease is normal. The optimum way of recording the observation in the case record is this: "pulsus paradoxus of ___ mm Hg." This shows that pulsus paradoxus of a normal degree was actually sought and gives the careful reader the opportunity to apply his own criteria (10 mm Hg or 10% of the expiratory systolic pressure) to the observation. The more common practice of noting pulsus paradoxus only if "present" and not if "absent" requires the reader to perform two separate acts of faith.

Respirations

Both the rate and the character of the respirations should be described, for example, 24 per minute and grunting; 13 per minute, regular and easy; and 7 to 10 per minute and regularly irregular (Cheyne–Stokes).

Skin

If there is a rash or an eruption, it must be described sufficiently to permit an expert dermatologist to make a diagnosis. The points to be included are

1. Is it macular, papular, herpetic, or bullous? (A spot that is flat is called a *macule*. A lesion that is raised is called a *papule*. The differential diagnosis is completely different. If there are multiple lesions, some macular and some papular, the eruption would be described as maculopapular. There is no such thing as a single "maculopapular" lesion.) See Table 7-1 for a more complete list of types of lesions.
2. Where is it located? If the distribution is uneven, where does it predominate? For example, is it palmar or centripetal?
3. Describe an individual lesion. If it is a papule, does it have a white head, a black head, or no perceptible head? Is it surrounded by a halo? If there is a halo or any other type of border phenomenon, is the border sharp or gradual, smooth, or serpiginous?
4. If possible, take a photograph or draw a diagram to include in the progress notes. At least provide a word picture indicating the most outstanding characteristics of the lesion, even (or especially) if they are not listed here. For instance, some macules blanch on pressure, even though we would not describe other skin lesions in such a dimension. The Nikolsky sign and the Koebner phenomenon are other examples (see Chapter 7).
5. The description must be sufficiently clear and detailed to provide a baseline for future progress notes. Sometimes, one later observes a change in a dimension not initially described. It is permissible to add to your baseline description in another color ink, dating the addition. An additional reason for describing skin lesions as precisely as possible is that a patient may develop a different eruption during his hospital stay. Consultants have sometimes been misled by assuming that the patient's rash was a recurrence of a previous one, rather than a new manifestation. This issue becomes increasingly important in teaching hospitals where members of the "team" change very frequently.
6. If you suspect that a patient may be developing a disseminated infection as with herpes, you may want to circle lesions with a ballpoint pen, count them, and then check again at a later time.

Lymph Nodes

A homunculus may be stamped in the record for showing the position and size of lymph nodes (Fig. 4-1) or for other findings such as the location and radiation of pain.

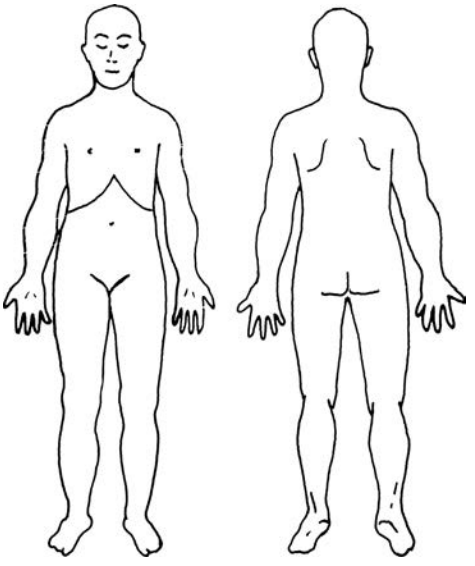

FIGURE 4-1 Diagrams that may be stamped in the progress notes to record serial examinations of the lymph nodes. (Courtesy of Dr David Clarkson, Mobile Alabama.)

Eyes

Describing Nystagmus

Some authors name nystagmus for the direction of gaze in which the nystagmus appears. Others name it for the quick return component. As the former system will not work for fixation nystagmus and the latter will not work for pendular nystagmus, the method should be specified as part of the case report (e.g., "horizontal nystagmus on gaze to the right, quick component to the right", or "primary position vertical nystagmus, quick component down").

Diminution in optokinetic nystagmus is described in the record as being from that side of the patient in which the drum (or tape) was being rotated when the defective response was found. This is also the same side from which the slow initial phase of nystagmus moved and the side toward which the rapid jerk recovery component was aimed. (For a more advanced discussion, see Chapter 10.)

Ears

A normal Rinne and Weber test (see Chapter 11) would be described as follows: "AC > BC bilat. Weber midline." This "normal" finding can also be seen in bilateral partial sensorineural deafness. This illustrates the point that one should never make an entry "normal" in the history and physical portion of the chart; "normal" is, after all, a conclusion from the data, not the actual data.

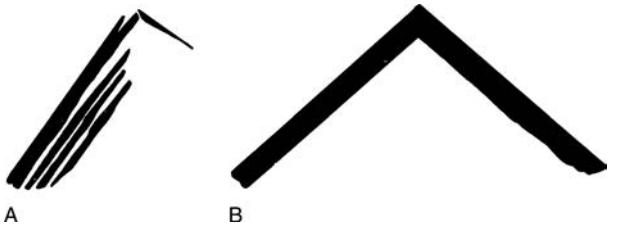

FIGURE 4-2 One notation for breath sounds. The upslope of the inverted V represents inspiration and the downslope represents expiration. **A:** Soft (vesicular) breath sounds. **B:** Loud tubular breath sounds.

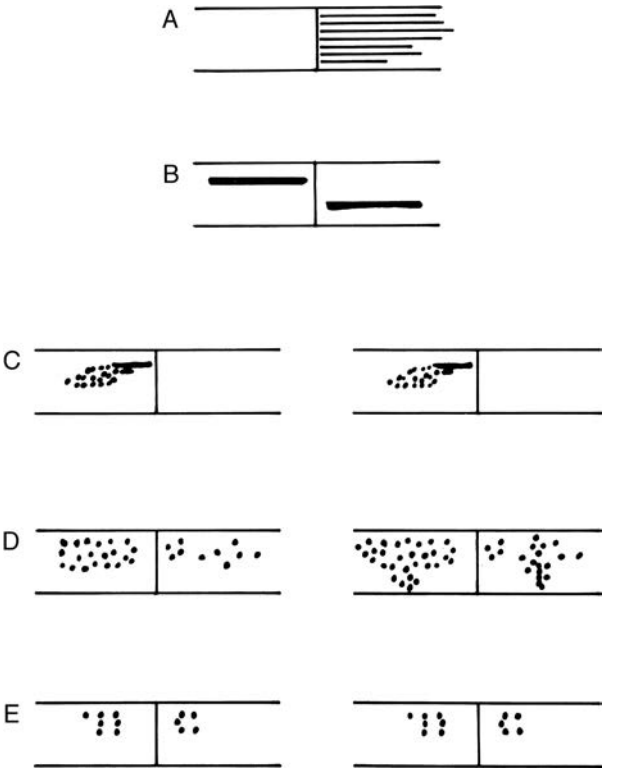

FIGURE 4-3 Forgacs notation. Inspiration is shown to the left and expiration to the right of the vertical bar. To indicate whether the events are recurring or random, show two sequential respirations, with either the same or different patterns. **A:** Expiratory polytonic wheeze. **B:** Inspiratory and expiratory monotonic wheezes. **C:** End-inspiratory crackling and wheeze of recurrent pattern. **D:** Inspiratory and expiratory crackling of random pattern. **E:** Inspiratory and expiratory crackling of recurrent pattern.

Auscultation of the Lungs

A diagram of the anterior and posterior aspects of the chest (see Chapter 16) is helpful for indicating the region in which findings are auscultated. For describing the breath sounds, an inverted V has traditionally been used. Inspiration is always shown on the left and expiration on the right. The relative duration of the phases may be demonstrated by altering the lengths of the two wings of the V (Fig. 4-2).

An Alternate Method

For adventitious sounds, Forgacs (1969) introduced the system of notation shown in Fig. 4-3. To understand his notation, you need to understand something about pathophysiology. After reading the section on auscultation in the chest chapter and before reading the correct answers, which appear in Appendix 4.1, come back to this figure and identify the significance of each of these auscultatory patterns. Please note that there are at least two answers for the last pattern.

Auscultation of the Heart

Heart Sounds

In Chapter 17, you will learn how much information can be obtained from observing the intensity of the heart sounds and the

pattern of splitting of the second heart sound. It is important to record these observations. If the first heart sound (S1) is not louder than the second (S2) at the apex or if the first heart sound is not of a constant intensity, the finding is of great pathophysiologic significance. Most of the time these abnormalities are absent; the fact that they were sought and not observed should also be noted, by stating "S1 > S2 and constant."

The second heart sound splits into a pulmonic and an aortic component, P2 and A2, respectively (see Chapter 17). Please note that P2 is not the total intensity of the second heart sound as heard in the pulmonic area, and A2 is not the total intensity of the second heart sound in the aortic area. (If one wished to record those, although such information is not at the optimal level of sophistication, they would be denoted "S2 at the pulmonic area" and "S2 at the aortic area," respectively.)

Most subjects have no abnormality in the splitting of the second heart sounds, and the pulmonic component will not be louder than the aortic component. The examiner should then record: "S2 splits normally; A2 > P2." This statement implies that S2 splitting was detectable with inspiration (sometimes it is not) and that its components have been compared at the pulmonic area (or wherever the distinct components are best heard). In some normal situations, the aortic and pulmonic components are equal and the second part of the statement would be modified: "A2 = P2."

Murmurs

Dimensions

It is imperative that any cardiac murmur be described in all the appropriate dimensions:

1. *Timing:* Is the murmur systolic, diastolic, continuous, or to and fro? (See also the Rule of Two Diastoles below.)
2. *Shape:* Is it decrescendo, decrescendo–crescendo, diamond shaped, or holosystolic?
3. *Location:* Where is the murmur loudest?
4. *Radiation:* Where else may it be heard? And where is it not heard (e.g., axilla, right midclavicle)?
5. *Pitch:* Is it high, low, rumbling, or other?
6. *Timbre:* Is it coarse, musical, or other?
7. *Intensity:* How loud is it, on a scale of 1 to 6 (see Chapter 17)?
8. *Special maneuvers:* What was the effect of standing, rolling into the left lateral decubitus, leaning forward, squatting, releasing a Valsalva maneuver, and so forth?

Some murmurs are unremarkable in terms of pitch or timbre, and if this is your judgment, state it. However, do not omit the statement "unremarkable" in favor of no statement at all.

Rule of Two Diastoles

It is convenient to assume the fiction that there are two diastoles for every systole, an early diastole and a late diastole. In the section on cardiac examination, we will emphasize the importance of listening to them one at a time. Early diastole (protodiastole) is heard immediately after the second heart sound; late diastole (presystole) is heard just before the first heart sound. The timing is of great diagnostic significance, and all diastolic murmurs, gallops, snaps, plops, knocks, clicks, and rubs should be described as occurring in early or late diastole.

Vascular Examination

For grading the arterial pulses, there are several different systems. Some schools teach that the pulses should be graded so that 2+ is normal, 1+ is abnormal but palpable, and 0 is absent. Others teach that 3+ is normal, 4+ is bounding, 2+ is subnormal, and 1+ is palpable only after a careful search. Still other schools teach a system based on a scale of 0 to 6+. Accordingly, it is important to note somewhere on the record which system is being used. Also, it is more important to find asymmetries than to obtain an exact gradation. Therefore, your recording system must have a place to indicate lateralization.

If your institution has no standard for gradation of pulses, I suggest the following:

0: No palpable pulse is found.
±: Sometimes you do not feel it and sometimes you think you do. (Check your own pulse simultaneously and make sure it is not the pulse in your own fingers that you are feeling.)
1+: You are sure that you can feel the pulse most of the time, but you would not be able to count it for a minute if the patient were in atrial fibrillation.
2+: You can feel the pulse all the time, but it seems weaker than your own.
3+: It feels like the pulse of a normal 25-year-old.
4+: The pulse is bounding, and you expect to find a widened pulse pressure.

Here is an example of a recorded examination of a male patient:

	L	R
Carotid	2/4	2+
Subclavian	1+	1+
Brachial	3+	3+
Ulnar	1+	1+
Radial	3+	3+
Femoral	3+	2+
Popliteal	1+	0
Dorsalis pedis (DP)	2+	1+
Posterior tibial (PT)	2+	1+

The "2/4" notation for "carotid" indicates that the clinical grading scale ranges from 0 to 4. In this case, it does not matter if the left PT is exactly as strong as the right ulnar or if the right DP is the same as the left carotid.

What we can see at a glance is that this patient needs some lower extremity blood pressure measurements, a DeWeese test (see Chapter 18), careful auscultation of the left femoral, and detailed questioning about sexual potency and claudication of the buttock.

Joint Examination

A homunculus can be used to record serial examinations of the joints (Fig. 4-4).

Neurologic Examination

The cranial nerves are referred to by the appropriate Roman numerals. Deep tendon reflexes and the Babinski reflex may be recorded efficiently by means of a stick man (Fig. 4-5).

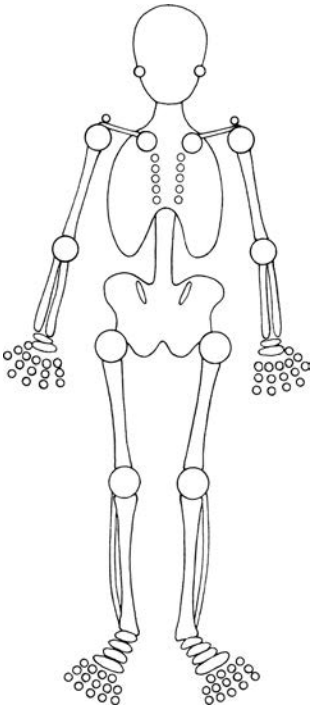

Figure 4-4 Diagram for recording serial examinations of the joints. (From Polley HF, Hunder GG. *Rheumatologic Interviewing and Physical Examination of the Joints*. 2nd Ed. Philadelphia, PA: W. B. Saunders; 1978, with permission.)

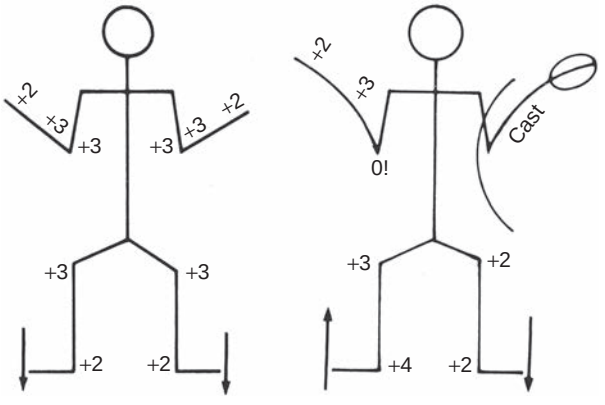

Figure 4-5 A method of recording deep tendon reflexes and the Babinski reflexes.

The phrase "decreased mental status" should never appear in the medical record. Persons who use this phrase to mean an impairment of cognitive function or an altered state of consciousness tend to forget that there are additional dimensions to the mental status examination. Once they omit proper recording of all dimensions, they soon omit the proper examination of these dimensions and so fail to attend to the different types of diseases that can be reflected in the examination.

Differential Diagnosis

The differential diagnosis is a list of alternate explanations for a given sign, symptom, or laboratory test, arranged in descending order of probability. Stated another way, it is a list of testable hypotheses. It is expected that one of the diagnoses on the list is the correct one and that it can be established by specific laboratory tests or by excluding all the other items on the list.

It is possible to compose a differential diagnosis that explains not just one sign, symptom, or laboratory test but multiple combinations of findings. However, the beginning student is advised to indicate formally which one finding is to be explained by each list. The use of differential diagnostic lists is explained more fully in the chapter on clinical reasoning (see Chapter 27). For the present, let us simply point out some advantages of including the differential diagnosis in the case record.

The differential diagnosis structures the HPI and provides a guide for checking both the history and the physical examination for completeness. Much of the information pertinent to ranking the individual items in the differential diagnosis, or excluding them, should be in the HPI. The information may be in the chronologic section or at the end in the pertinent positives and negatives. (In about 10% of the cases, the critical information will be derived from the physical examination rather than from the HPI.)

Initially, the student will not know enough about diseases and medicine to utilize the differential diagnosis to its fullest capacity. However, it will serve him as a reading guide. When I grade sophomore medical student papers, I begin by reading the chief complaint and HPI. As soon as I become confused, I skip all the way to the differential diagnosis, which should tell me what the student was thinking about when he composed his history. The student is advised to spend a great deal of time developing with the aid of a preceptor the skill of composing an HPI that fits the differential diagnosis. He should rewrite his HPIs as many times as necessary, just as he rewrote essays in college composition classes. As with other skills, such as playing the piano, skiing, or fighting bulls (see epigram in Chapter 6), assiduous practice of the basic skills at the beginning will pay handsome dividends later. For a skilled clinician, the interview itself contains a series of hypothesis tests concerning potential diagnoses. In summary, the composed HPI is a reflection of the implicit logic in the differential diagnosis. The ability to relate these topographically disparate portions of the case record is an acquired skill.

Acquired skills are learned through repetition.

Laboratory Data

At an earlier time, the only laboratory data that were initially entered in the case record were those that the medical student and house officer performed themselves. Thus, it was perfectly appropriate to give one's differential diagnosis and impressions right after the history and physical and to use them as a guide to determine which diagnostic tests to perform. Times change.

More recently, I found an intern chastising a medical student for recording his impressions on the basis of "just" the history and the physical. Only the laboratory tests were defined as "data" by this intern, even though they were either inappropriate or predictable from the clinical findings! This scene was a manifestation of the pecking-order phenomenon, not of science.

Bedside Presentation

The student attending an institution without a tradition of bedside presentation can gather the essentials by reading the appropriate section in Morgan and Engel (see Chapter 29) and using the form given earlier in this chapter. Here we point out a few basics.

One should not read the case report at the bedside. The ability to present with at most a few notes is a sign that the student has taken sufficient time to organize his thoughts about the case in a coherent, logical manner. A poorly organized assortment of thoughts is difficult to remember.

It has been a practice to avoid certain expressions at the bedside and to substitute euphemisms. Syphilis has been called lues or treponemes; cancer, mitotic activity; gonorrhea, Neisser organism; and alcohol, C_2H_5OH or two-carbon fragments. An intimation that pertinent information cannot be discussed in front of the patient has been conveyed by saying "there is concern about the number of eighth cranial nerve synapses at the present time." A thoughtful person is invited to invent his own euphemisms when necessary. Always respect the patient's sensibilities and intelligence.

Also, to be eschewed are phrases such as "he pointed to" and "I asked him," which are redundant and should be omitted. It is already assumed that the patient is the source of the information unless another informant is named.

The general appearance section should be omitted during the bedside presentation unless it has changed since the original examination. Then one might say, for example, "He was as you see him now except that he was sitting straight up in bed, gasping for air."

Some are offended by the use of the terms "male" or "female." It is best to use "man" or "woman." Similarly, terms describing the patient's race or ethnicity can easily give offense. If one fears the political thought police, it is best to refer to the local stylebook while remembering that the accepted terminology may change and usually does not describe the natural characteristics of human beings very well.

Introduce the patient as a person, not as a specimen of a particular sex, age, and race. Refer to the person by name ("Mrs. Jones"), not anonymously as "the patient."

About Race and Ethnicity

The word "race" was first used in 1775 by Blumenbach, a German anthropologist and anatomist, to classify human beings into five divisions: Caucasian, Mongolian, Ethiopian, American, and Malay. Since then, between 30 and several hundred races have been defined using anthropologic criteria. In the 1990 U.S. census, nearly 300 "races" were volunteered (Witzig, 1996).

The medical justification for taking note of a patient's race is that one's genetic endowment affects the prior probability of a particular diagnosis as well as response to therapy. Even the most obvious example, sickle cell anemia, shows the hazard of relying on racial taxonomy. Witzig presents the case of an 8-year-old phenotypically European boy who nearly underwent laparotomy for abdominal pain before his sickle cell crisis was diagnosed and of a 24-year-old man classified as black who exsanguinated from a peptic ulcer while being treated for sickle cell crisis without a confirmed diagnosis of sickle cell disease or trait (Witzig, 1996).

The once-accepted adjective "Negro" was replaced by "black" when this author was a medical student but is often replaced by "African American" these days. Such terms are not used in this book because it is genotype, not nationality or geographic origin, that is of biologic importance. Many persons born on the continent of Africa are not of the Negro or black race. Similarly, it would be very confusing to refer to a person from the Indian subcontinent as an Asian American.

According to the Associated Press stylebook, "black" is preferable to "African American." In an informal survey, 40% of copy editors agreed. Only 20% favored "African American," and the rest chose "other" or selected one of the two terms depending on the context (Henry, 2004).

The correct adjective is "Jewish," not "Jew," although again the information is not pertinent unless Tay-Sachs or another disease occurring in Jews is to be a consideration. In that instance, one might need to proceed further and describe the patient as Ashkenazic or Sephardic. Groups with wide phenotypic representation should not be grouped together, especially if they have experienced social repression. Swarthy Jews may not care to hear at the bedside that they are "Jewish appearing."

The patient's ethnic and cultural background is very important in his experience of illness, as well as a possible indicator of certain risk factors. Be aware that certain labels such as "Hispanic" lump together a large number of diverse groups with different genetic as well as cultural backgrounds.

An American who emigrated from Colombia may resent being called a Mexican. A nurse who referred to herself as a Mexican (natal country) pointed out to me that older Mexicans often resent being called *Chicanos*, especially if female (the feminine form is *Chicana*), even though contemporary dictionaries define the word to mean an American of Mexican ancestry (Raventós and Gold, 1999). Originally, the word was used as an insult by one group of Mexicans, who were in turn called *pochos* (faded, discolored) because they were losing their language and culture. The Spanish word *chicana* means "chicanery" (Raventós and Gold, 1999), and *chicanero* means "tricky" or "cunning" (Cuyás, 1940). The nurse was so offended at having the word *Chicano* on her nursing license that she sent it back to the state capital to have it changed. Younger persons may not find the term objectionable.

When you feel it is necessary to describe the patient's race or ethnic group and are in doubt about the proper term, it is best to inquire of the patient. Common sense, courtesy, and *willingness to listen to the patient* are the main requirements for successfully handling sensitive issues.

Rules for the Attending: Conversing with a Resident About a Patient

1. Statements beginning with any of the following phrases are least likely to contain information useful in diagnosis and treatment:
   "They say that…."
   "I heard that you should…."
   "Omphalology (or the name of any other specialty) said…."
   "Dr Smith said…."

"We were told…."
"It's taught us that…."
"Because they say that you're always supposed to…."
And my all-time favorite: "My roommate is dating a cardiology fellow at St Noodnik, and she said that he said…."

2. Statements beginning with any of the following phrases are highly likely to contain information useful for diagnosis and treatment:
"Because …"
"If you are willing to assume …"
"I saw …"
"I heard …"
"I found a …"
"The nurse noticed …"
"I thought so too, but when we measured it …"

On Preparing for Presentation

The best way to decide what information to include in the presentation is to "think backwards." For each significant problem or diagnosis, decide what historic or clinical data are helpful in supporting the diagnosis or excluding alternatives so that you can present the most important positive findings and a few pertinent negatives. The goal is to provide selected and processed data in a lucid, brief, and precise manner.

On some occasions, especially when presenting to busy consultants, a "newspaper style" may be best, starting with the most important and dramatic facts (Chop, 1997).

Appendix 4.1

Forgacs Notation: Pathophysiologic Explanations

The sounds diagrammed in Fig. 4-3 can be explained as follows:

1. Expiratory polytonic (polyphonic) wheezing results from expiratory collapse of the lobar bronchi in diffuse airway obstruction.
2. The inspiratory and expiratory monotonic pair of wheezes results from a single rigid airway narrowed to the point of closure.
3. Recurrent end-inspiratory crackling and a terminal inspiratory wheeze, alone or together, are explained by the delayed opening of small airways in deflated territories of the lung.
4. Inspiratory and expiratory crackling in a random pattern is a result of the inspiratory and expiratory gurgling of liquid in airways.
5. Inspiratory crackling in a recurrent pattern is attributed to the delayed inspiratory opening of small airways. Expiratory crackling in a recurrent pattern is attributed to expiratory air trapping in deflating territories of the lung. If occurring together, they may signify a combination of the above, or according to Forgacs, they may be a sign of pleural friction.

Appendix 4.2

A Spanish–English Case Record

The patient may be asked to fill out the form prior to the visit. The English terms are technical for brevity, the Spanish idiomatic.

Historia Médica

Información sobre su salud previa es muy importante para el doctor. Por favor conteste las siguientes preguntas antes de ver al doctor. Señale con una equis (X) abajo sí o no.

Fecha (date) ___
Nombre (name) ___ Edad (age) ___
¿Qué clase de trabajo hace? (occupation) ___
Estado civil (marital status): casado, soltero, divorciado, viudo (M, S, D, W)
¿Cuántos hijos tiene? (no. of children) ___
¿Cuántos cigarillos se fuma al día? (amount smoked) ___
¿Qué cantidad de alcohol consume? (amount of alcohol consumed)___
Enfermedades en su familia: (illnesses in your family)
Padre (father):___
Madre (mother): ___
Hermanos (siblings): ___
Hijos (children): ___
Otros (others): ___

Alergias (allergies):	*Sí*	*No*	
Penicilina (penicillin)	___	___	
Otras drogas (other drugs) (which?) ___	___	___	¿Cuales?
Comidas (foods)	___	___	¿Cuales? ___

¿Qué medicamentos toma actualmente? (current medications)
_____
Señale con una equis (X) si ha tomado algunas de estas medicinas: (Have you ever taken …?)
_____ Píldoras anticonceptivas (oral contraceptives)
_____ Anticoagulantes (anticoagulants)
_____ Diuréticos (diuretics)
_____ Medicina para el corazón (heart medicine)
_____ Medicina para tuberculosis (drugs for tb)
_____ Medicina para glaucoma (glaucoma medicine)
_____ Calmantes (tranquilizers)
_____ Cortisona (corticosteroids)
¿Qué cirugías ha tenido? (Operations) ___
Accidentes o heridas (Injuries): ___
Otras hospitalizaciones (no incluya embarazos normales): (Approx. date and reason for hospitalization, excluding normal deliveries)

Fecha (aproximada)	Causa
___	___
___	___
___	___
___	___

Inmunizaciones:	Fecha
tétanos	___
polio	___
sarampión (measles)	___
rubeola (rubella)	___
papera (mumps)	___
hepatitis A	___
hepatitis B	___

otras

____ ____
____ ____
____ ____

¿Qué problemas tiene actuales? (What are your problems now?)

Sí No

Salud General (General Health)

___ ___ Aumento o pérdida de peso recientemente (Recent weight change)
___ ___ Fiebre, escalofríos o sudor nocturno (Fever, chills, night sweats)
___ ___ Pérdida de apetito (Anorexia)

Sistema Endocrino (Endocrine System)

___ ___ Intolerancia al calor o al frío (Heat or cold intolerance)
___ ___ Enfermedades de tiroides (Thyroid disease)
___ ___ ¿Ha tenido tratamientos de radiación en el cuello? (Radiation to neck)
___ ___ ¿Ha tenido diabetes? (Diabetes, glucosuria)
___ ___ Historia de diabetes en la familia (Family history of diabetes)

Piel (Skin)

___ ___ Comezón (Itching)
___ ___ Sarpullido (Rash)
___ ___ ¿Tiene lunares negros o marrónes que han cambiado? (Change in mole)

Musculoesquelético (Musculoskeletal)

___ ___ Dolor en las articulaciones o artritis (Joint pain)
___ ___ Hinchazón en las articulaciones (Joint swelling)
___ ___ Rigidez por la mañana (Morning stiffness)

Ojos (Eyes)

___ ___ Cambio de la visión (Change in vision)
___ ___ Halo alrededor de luces (Halos around lights)
___ ___ Otros síntomas (Other symptoms)

Otorrinolaringología (ENT)

___ ___ Pérdida de oído (Loss of hearing)
___ ___ Zumbidos del oído (Tinnitus)
___ ___ Hemorragia nasal (Nosebleed)
___ ___ Ronquera, cambio de voz (Hoarseness, change in voice)
___ ___ Vértigo o sensación de dar vueltas, mareo (Vertigo)

Sistema Respiratorio (Respiratory System)

___ ___ Resuello, asma, jadeo (Wheezing, asthma)
___ ___ Tos (Cough)
___ ___ ¿Al toser, escupe flema? (Sputum)
___ ___ ¿Ha estado expuesto a tuberculosis? (Tuberculosis exposure)
___ ___ ¿Ha tenido prueba de la piel para tuberculosis? (PPD done?)
___ ___ ¿Fué positiva la prueba de la piel? (PPD positive?)
___ ___ ¿Ha escupido sangre? (Hemoptysis)
___ ___ ¿Ha tenido radiografía del tórax anormal? (Abnormal chest film)

Corazón y Circulación (Cardiovascular)

___ ___ ¿Respira con dificultad? (Dyspnea)
___ ___ ¿Tiene que sentarse por la noche para poder respirar? (Paroxysmal noctural dyspnea)
___ ___ Palpitaciones del corazón (Palpitations)
___ ___ ¿Se ha desmayado? (Syncope)
___ ___ Hinchazón de las piernas o los tobillos (Pedal edema)
___ ___ Dolor en las piernas al caminar (Claudication)
___ ___ Fiebre reumática (Rheumatic fever)
___ ___ Coagulación de la sangre (Blood clots)
___ ___ Murmullo del corazón (Heart murmur)
___ ___ Enfermedad previa del corazón (History of heart disease)
___ ___ Enfermedad del corazón en su familia (Family history of heart disease)
___ ___ Alta presión sanguínea (Hypertension)

Gastrointestinal (GI)

___ ___ Náusea (Nausea)
___ ___ ¿Ha vomitado? (Vomiting)
___ ___ ¿Ha vomitado sangre? (Vomiting blood)
___ ___ Úlcera péptica (Peptic ulcers)
___ ___ Acidez, agruras de estómago (Heartburn)
___ ___ Problemas al tragar (Dysphagia)
___ ___ Dolor en el abdomen (Abdominal pain)
___ ___ Hinchazón del abdomen (Abdominal swelling)
___ ___ Piel amarilla, ojos amarillos, orina marrón (Jaundice, brown urine)
___ ___ Cambios intestinales (Change in bowels)
___ ___ Estreñimiento (Constipation)
___ ___ Diarrea (Diarrhea)
___ ___ Excremento negro o alquitranado (Melena)
___ ___ Enfermedad de la vesícula (Gallbladder disease)
___ ___ Pancreatitis (Pancreatitis)
___ ___ Hepatitis (Hepatitis)

Hematológico (Hematologic)

___ ___ Bolitas en las axilas, el cuello o la entrepierna (Lumps in axilla, neck, or groin)
___ ___ Anemia (Anemia)
___ ___ Tendencia a sangrar (Bleeding tendency)

Genitourinario (Genitourinary)

___ ___ ¿Se despierta en la noche para orinar? (Nocturia)
___ ___ Molestia al orinar (Dysuria)
___ ___ Pérdida del control al orinar (Incontinence)
___ ___ Sangre en la orina (Hematuria)
___ ___ Infección en la orina o los riñones (Urinary infections)
___ ___ Cálculos o piedras en los riñones (Stones)
___ ___ Enfermedad venérea (Venereal disease)
___ ___ Historia en su familia de enfermedad de los riñones (Family history renal disease)

Para Hombres Solamente (For Men Only)

___ ___ Disminución del chorro de la orina (Diminished stream)
___ ___ Hinchazón o molestia en el escroto o testículos (Testes)
___ ___ Problemas sexuales (Sexual difficulties)
___ ___ ¿Le supura el pene? (Penile discharge)

Para Mujeres Solamente (For Women Only)

___ ___ Secreción o flujo vaginal (Vaginal discharge)
___ ___ Irritación de la vagina (Vaginal irritation)
___ ___ Periodo menstrual anormal (Abnormal menses)
___ ___ Sangrado entre períodos menstruales (Spotting between periods)
___ ___ Cambios después de la menopausia (Postmenopausal bleeding)
___ ___ Bolitas en los senos (Lumps in breasts)
___ ___ Dolor durante las relaciones sexuales (Dyspareunia)
___ ___ ¿Usa algún método para evitar embarazo? (Use of any birth control method)
___ ___ Aborto provocado (Induced abortion)
___ ___ Alguna complicación del embarazo (Complications of pregnancy)

Fecha del último período menstrual (Date of last menses) ___
¿Cuántos embarazos? (No. of pregnancies) ___
¿Cuántos abortos naturales? (No. of spontaneous abortions) ___ provocados (induced)___
¿Cuántos niños han nacido vivos? (No. of live births) ___
¿Cuántos niños han nacido muertos? (No. of stillbirths) ___
¿Cuántas cirugías de cesárea? (No. of Cesarean sections) ___

Neurológico (Neurologic–psychiatric)

___ ___ Dolor de cabeza (Headache)
___ ___ Visión doble (Double vision)
___ ___ Ataques (convulsiones) (Seizures)
___ ___ Cambios en el estado de ánimo (Changed sensation)
___ ___ Debilidad en alguna parte del cuerpo (Weakness in any body part)
___ ___ Torpeza al caminar (Clumsiness)
___ ___ Cambio de personalidad (Change in personality)
___ ___ Pérdida del equilibrio (Loss of equilibrium)
___ ___ ¿Se despierta muy temprano en la mañana? (Early awakening)
___ ___ ¿Pérdida de interés en actividades divertidas? (Anhedonia)
___ ___ ¿Ha pensado suicidarse? (Suicidal thoughts)

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CHAPTER

5

General Appearance

You can observe a lot by watching.
—Yogi Berra (quoted by Dr Ben Friedman of Alabama)

Points to Remember:

- Your ability to do a good clinical examination increases with your medical knowledge.
- The skilled clinician can often draw many diagnostic conclusions from his first look at the patient.
- If you are not looking for something, chances are you won't see it, even when it is present.

Before beginning the sequential physical examination, it is important to take a moment just to look at the patient. Unless one's brain has been designed by nature to be like that of Arthur Conan Doyle's medical school teacher, Dr Bell (see Chapter 26), one must systematically seek and record specific observations about the patient's general appearance. I still suggest to medical students that they read the stories about Sherlock Holmes (who was modeled on Dr Bell) to learn the excitement of drawing inferences from precise observations, but the student will continue this practice only if reinforced by success. Unfortunately, he will not achieve that success unless he knows what to look for. As Goethe said, "*Was man weiss, man sieht*" (what one knows, one sees).

On a piece of scratch paper, write down what season of the year is referred to in the phrase in Fig. 5-1. If you wrote down the word "spring," you are correct. No doubt, you read the sign as saying "Paris in the spring." However, that is not what it says. Go back and read it again, and if you still see the same thing, read it aloud, word by word, pointing at each word on the sign with your finger.

Most students feel that this sign is only a trick. They see their patients everyday and cannot believe that something repeatedly exposed to their careful gaze would escape them. Accordingly, I suggest that you perform the following experiment on yourself, carefully following the steps in sequence.

1. Get a large piece of paper and a pen or pencil.
2. Take off your wristwatch and put it in your pocket or purse.
3. Draw the face of your wristwatch on the piece of paper. (If you have a digital watch, think of a clock face that you often see, such as your night table or kitchen clock.)
4. Now draw the hands, specifically indicating their shape and any markings on them.
5. Indicate the color of the hands and the color of the background.
6. Show the markings for the hours. What color are they? Are they Roman or Arabic numerals? Are any numerals omitted, and what kind of mark is used in their place, if any?
7. Mark exactly on your drawing any words printed on the face of your watch and any other outstanding marks.
8. Finally, take your watch out and compare its face with your drawing. How many false-positive memories did you have (i.e., markings on your sketch that do not actually exist on the face of the watch)? How many false-negative memories (i.e., markings on the face of the watch that you did not draw on your sketch)? How many thousands of times do you think you have glanced at this watch?

This exercise is intended to demonstrate that mere unstructured examination will not yield the most obvious of data, no matter how many times it is repeated, unless one is specifically looking for something. Although the outstanding diagnostician differs from the mediocre more in the way that he handles data than in the data that he collects, the importance of observation cannot be overemphasized: The superior clinician cannot gather too much information.

A Method

The principle of having a methodical search in mind before you begin the examination will be an underlying implicit emphasis of the remainder of this text. One sees what one looks for. Ironically, the general appearance section per se lends itself least to a methodical scheme. Take care to observe the following aspects of the general appearance when first meeting the patient (see Rodnan's outline in Chapter 4): development, nutrition, apparent state of consciousness, apparent age, race, sex, posture or position in bed, comfort, attitude toward examination, degree of illness (acute or chronic), movements, habitus, and body proportions.

Morgan and Engel have stated that the general appearance section of the write-up should contain sufficient succinct material to permit a stranger, should he walk through the wards, to immediately identify the patient you are describing. It may include features of the patient that might also be included in a specific part of the physical examination, (especially the skin, facial appearance, or neurologic examination) but that are apparent to the methodical observer who is meeting the patient for the first time. Some syndromes, especially congenital ones, make the patient look unusual (i.e., "funny looking"). It is the observer's job to describe just what is unusual about the patient's looks.

This text will focus primarily on just three aspects of the general appearance for illustrative purposes: position and posture, movements, and habitus and body proportions. Additional illustrations are given in Chapter 9. This text will not follow the pattern of most other clinical diagnosis textbooks, that is, reciting a list of descriptions for the *cousin diseases* (so called because all the patients with the disease seem to have a family resemblance): hyperthyroidism,

Figure 5-1 Self-study Exercise. Write down the season of the year referred to on this sign, and see text p.85. (Courtesy of Dr Campbell Moses, New York, with permission.)

hypothyroidism, Addison disease, Cushing disease, acromegaly, gargoylism, and so forth. First, the pictures of very advanced cases that appear in textbooks are obsolete in that we now usually make the diagnoses much earlier. Second, if you are experienced enough to be able to recognize these patients from their textbook photographs, you do not need a verbal description repeated here.

For the Attending. Look at the devices attached to and the medications flowing into the patient. Professor Ask-Upmark would inspect the patient's bedside table for diagnostic clues and information about the patient's personality, religious beliefs, and social support system. Look at the orderliness with which things are arranged. Look for the type of reading material that is present, if any. Inspect the clothing. Dr Bill Domm of Virginia inspected the shoes of patients he suspected of malingering to see whether the soles were worn in the pattern predicted from the abnormal gait that they displayed. There is no specific place in the record for such observations. They might be placed in the history or the physical examination, under general appearance, according to the taste of the individual.

Position and Posture

Patients with Abdominal Pain

In patients with abdominal pain, the position may be of particular value in the differential diagnosis. Patients with a perinephric abscess tend to bend toward the side of the lesion (see Chapter 20 and Fig. 20-7). Patients drawn up in the fetal position often have pancreatitis. Patients who are restless in their agony probably have some form of obstruction, whereas patients with peritonitis tend to hold themselves quite still (Silen, 1979).

A patient who is lying on his back with his knee flexed and his hip externally rotated is said to have the *psoas sign* (Fig. 5-2). Formerly considered a sign of peritoneal irritation (resulting, for example, from appendicitis or an abscess associated with regional ileitis or diverticulitis), in modern medicine, it is more frequently seen with disease inside the psoas muscle itself, such as an abscess or iatrogenic hemorrhage due to anticoagulation (see also the reverse psoas maneuver in Chapter 20).

Patients with Breathing Difficulty

Posture may also be a helpful clue for diagnosing conditions that cause breathing difficulties. Several positions, each with pathophysiologic significance, have been described.

Figure 5-2 The psoas sign is usually elicited with the patient supine, not erect. (After Andrea del Castagno's Saint Sebastian.)

Orthopnea

Cardiac Orthopnea

Orthopnea (literally, "straight up breathing") signifies left-sided congestive heart failure more than 95% of the time. The pathophysiology of orthopnea is rooted in the anatomic fact that in the erect posture, only the left heart remains centered in its (pulmonic) venous system, whereas the right heart becomes higher than most of the (systemic) venous system that supplies it. (In the supine posture, both the right and the left heart are centered in their respective venous systems.) In other words, when the patient is erect (standing or sitting), the right ventricle experiences a lowering in its filling pressure relative to the left ventricle. This may selectively decrease right ventricular output to the point that the fluid-filled lungs can now be cleared by the (weakened) left ventricle. This mechanism also explains why patients with pure right-sided heart failure do not experience orthopnea and why patients with left-sided heart failure experience some relief of their breathlessness when right-sided heart failure supervenes.

Patients with pulmonic stenosis may say that they can breathe better with their heads propped up on several pillows than when lying flat. There are also situations in which an increase in abdominal contents will make it easier for the patient to breathe when

sitting up. Whereas technically these are examples of orthopnea, they do not signify left ventricular failure and do not result from the pathophysiologic mechanism described above.

Pulmonary Orthopnea

If there is severe bilateral apical disease with relative sparing of the bases of the lungs, the patient may have orthopnea, since assuming the recumbent position will increase perfusion to the unventilated part of the lung and decrease oxygenation. On sitting up, such patients will again preferentially perfuse the better ventilated bases of their lungs, increase oxygenation, and decrease the sensation of breathlessness, thus mimicking the orthopnea of congestive heart failure.

Patients with severe obstructive pulmonary disease may also sit up in order to brace themselves (see Fig. 7-1A) to immobilize the thorax proper and improve the efficiency of the accessory muscles of inspiration. Leaning forward also helps by compressing the abdomen. The increase in the intra-abdominal pressure pushes the flattened diaphragm of the emphysematous patient back up into a more rounded dome, increasing its efficiency as the piston of respiration (Sharp, 1986). Over a long period, this posture may lead to pigmented patches where the patient has braced his elbows on the thighs (see Fig. 7-1B).

Orthopnea can also occur in asthma. In fact, asthmatic patients who are sweating and sitting up have worse pulmonary functions than those who are not (Brenner et al., 1983).

Paroxysmal Nocturnal Dyspnea

To obtain relief from cardiac paroxysmal nocturnal dyspnea, patients may report going to the window for "better air." In reality, leaning on the window helps to support the fatigued body in an erect position; it is the standing that is important, the rest being cerebral elaboration. Patients with pulmonary disease brace themselves against windowsills. Patients with either cardiac or pulmonary dyspnea may also get up and go to the window just to have some cold air blow on their faces because this reduces breathlessness even in normal subjects studied under conditions of hypercapnia and loaded breathing (Schwartzstein et al., 1987).

Platypnea

Platypnea (literally, "flat breathing") refers to the sensation of breathlessness when erect, with relief in the recumbent position. It is usually accompanied by orthodeoxia, which is a decrease in oxygen saturation in the erect posture when compared with the recumbent (*vide infra*). Platypnea was first described by Robin et al., who found it in a coal miner with severe pulmonary emphysema (Altman and Robin, 1969).

In any pulmonary disease that afflicts primarily the basal segments of the lungs, assumption of the erect or sitting position increases the ventilation/perfusion mismatch and causes the arterial oxygen saturation to decrease. Platypnea has been described in patients with multiple recurrent pulmonary emboli (Seward et al., 1984), necrotizing pneumonia with pneumatocele formation (Khan and Parekh, 1979), bilateral staphylococcal pneumonia, pleural effusion, tuberculosis (Limthongkul et al., 1983), patent foramen ovale (Horton and Bunch, 2004), and other conditions. Obviously, any arteriovenous communication in the bases of the lungs could also be considered a ventilation/perfusion mismatch, which could be aggravated in the erect position (Robin et al., 1976). Thus, platypnea with orthodeoxia has even been seen in the absence of any apparent pulmonary disease, such as in the presence of cirrhosis (Santiago and Dalton, 1977) in which case the existence of acquired arteriovenous malformations has been inferred. This hepatopulmonary syndrome, even in the absence of other complications or signs of decompensation, may signal that the patient is headed for a liver transplant (S. Danovitch, *personal communication*, 2004).

Trepopnea

Trepopnea (literally, "twisted breathing") was coined by Dr Richard A. Kern to indicate the preference of certain patients for the lateral recumbent position. This may result either from a pulmonary or a cardiac cause. As a rule, with unilateral lung disease, pulmonary gas exchange is maximized by placing the normal lung in the dependent position. There are exceptions (*vide infra*). Although recently popularized as a sign of pulmonary disease, trepopnea had earlier been observed in a large series of patients with congestive heart failure (Wood and Wolferth, 1937). In these patients, right trepopnea (right side down) was usual. It was suggested that the predominance of right-sided pleural effusions in congestive heart failure might be a result of the patient's preferred position.

One exception to the "good side down" rule is pleural disease accompanied by pleuritis in which the patient uses the bed as a way of splinting the painful side of the chest. A second exception in which the abnormal lung may be placed in the inferior position was reported in a patient with a recurrent bronchial carcinoma, postresection, in the left upper lobe stump. The mass occluded the remaining left lobar lobe when the patient was in the right lateral decubitus position, so the patient had left lateral decubitus trepopnea, with the normal lung up (Mahler et al., 1983). Infants are a third exception (Davies et al., 1985). Another potential exception would be patients with chronic obstructive pulmonary disease, in whom ventilation to the superior lung increases, as ventilation to the dependent, supposedly better perfused lung, decreases. If this study, based on only four patients and two controls, can be confirmed, it would suggest that patients with mild-to-moderate chronic obstructive pulmonary disease should never assume a lateral decubitus position (Shim et al., 1986).

Rare causes of trepopnea include atrial myxomas and hepatocellular and renal carcinomas, if they grow into the right atrium (Yasuhiro et al., 1983). The latter cause left trepopnea.

Movements

Although gait is discussed later under the neurologic examination, Dr Albert I. Mendeloff of Maryland points out that it is very useful to observe the patient's gait for nonneurologic as well as for neurologic conditions. Dr Mendeloff suggests weighing the patient yourself. Observe the patient's gait as you walk to the scale together, and pay attention to the manner in which the patient climbs onto the scale and off again. It is also useful to observe the patient's attempt to climb onto the examining table unassisted. These observations are in the tradition of the great French neurologist Charcot, who placed his examining room at the end of a long hall and arranged his desk so that when he opened the door he could see the patient

walking down the hall. In many cases, he had made the diagnosis before the patient had even entered the room.

Habitus and Body Proportions

Symphysis Pubis-to-Floor Measurements

Since the days of Herodotus, it has been known that a man's fingertip-to-fingertip span is approximately the same as his height ("crown to heel"). The length from the pubic symphysis to the floor is about the same as from the pubic symphysis to the crown (i.e., about half the total height). More precisely, the pubic symphysis-to-crown/pubic symphysis-to-floor ratio is normally 0.92 (SD = 0.04) in whites and 0.85 (SD = 0.03) in blacks (McKusick, 1970). (This is surely not unrelated to the fact that blacks are preeminent world-record holders in various track events.)

Abnormalities in this ratio are characteristic of certain conditions. Achondroplastic dwarfs, but not persons who are constitutionally short statured, have a ratio greater than 1.0 (the symphysis pubis-to-floor span is much less than half the total height). Patients with Marfan syndrome or "marfanoid habitus" (common in normal black persons) have a lower than normal ratio (the symphysis pubis-to-floor measurement is greater than half the height), whereas equally tall acromegalics do not. In Marfan syndrome, the arm span is also greater than the height (McKusick, 1970). For other findings characteristic of this syndrome see Chapters 10, 13, 16, and 24.

In achondroplastic dwarfs, the humeri and femora are relatively shorter than the forearms and lower legs. As these diagnostic distinctions can easily be made on other grounds, I personally do not use these measures very often.

In children, the skeletal changes may be the first sign of Marfan syndrome to be expressed. Recognition of these signs permits early treatment to protect the arteries. Tables of normal values are available but for sitting and standing heights rather than for the ratios we have mentioned. In childhood Marfan syndrome, the sitting height remains normal, whereas the standing height is in the highest percentiles for age.

Children's growth curves should be plotted on a graph showing 95% confidence intervals by age. These standards are widely available in pediatrics textbooks.

Weight: Distribution and Changes

The patient's weight and its distribution are important aspects of the body habitus. The examiner should look for evidence of changes in weight. New holes in the belt or a change in the hole that is used (the "belt sign") may show that the patient has lost weight or that, conversely, he has had an increased abdominal girth because of ascites. As a rule, the sharpest buckle groove indicates the most recent hole. The most worn buckle groove indicates the customary hole (also see Chapter 3).

Individuals with abdominally located ("apple") obesity are likely to be at risk for type II diabetes and also for atherosclerotic vascular disease. Equally overweight persons with thigh ("pear") obesity are less likely to have type II diabetes. The latter is more common in women and most frequently develops during pregnancy. A formula for expedient differentiation of the two types in women is

Diameter of waist/diameter of hips = 0.7 (in normals)

A result of less than 0.7 indicates "pear" obesity and one of more than 0.85 indicates "apple" obesity (Malcolm et al., 1988).

Body Mass Index

The most widely used formula for relating height and weight is the body mass index (BMI).

$$\text{BMI} = \text{weight (kg)}/\text{height (m)}^2$$
$$\text{BMI} = 704.5 \times \text{weight (lb)}/\text{height (in.)}^2$$

A BMI between 20 and 25 kg per m^2 is generally considered a good weight for most individuals. A BMI greater than 27 is considered overweight and a BMI greater than 30 defines obesity. Normal values vary with age and sex. With an Internet search, patients can readily find a calculator to determine what percentile they fit into. The calculation is unreliable in patients with abnormal fluid balance. It might also erroneously classified as overweight patients who are unusually fit, as muscle tissue is denser than fat.

Patients interested in improving fitness may have purchased a home device to measure bioelectrical impedance as a way of determining percentage of body fat, or they may be monitoring this factor at a health club.

HIV-associated Lipodystrophy

Patients with human immunodeficiency virus (HIV), especially when treated with highly active antiretroviral therapy, may develop a progressive syndrome characterized by central lipohypertrophy, peripheral lipoatrophy, hyperlipidemia, lipomata, and insulin resistance (Carr et al., 2003). The patients appear emaciated because of loss of subcutaneous tissue from the cheeks, arms, thighs, and buttocks, with prominent superficial veins. At the same time, the dorsocervical fat pad enlarges, forming a "buffalo hump"; the neck circumference expands by 5 to 10 cm because of increased chin fat, or "horse collar"; the breasts hypertrophy; and central truncal obesity occurs. The patients have been vulgarly described as "stick men with a protease paunch," although not all have been treated with protease inhibitors. In addition to the distressing disfigurement, patients are at higher risk from accelerated atherogenesis and other complications of hyperglycemia.

This syndrome should probably be named "antiretroviral therapy–associated lipodystrophy," since all the patients included in the study that developed the objective case definition (Carr et al., 2003) were receiving this treatment. Probably, 50% of more of HIV patients on antiretroviral therapy are afflicted (Milinkovic and Martinez, 2005). "Slim disease" or the AIDS wasting syndrome, recognized in Uganda early in the epidemic, primarily involved loss of nonadipose tissue without changes in fat distribution (Fuller, 2008).

Is the Patient in Pain?

Watch the patient's gait and movements, especially when he thinks he is unobserved. Physicians who see many pain patients, some of whom may be misrepresenting their symptoms to obtain drugs, may have windows in their office situated so that they can observe patients in the parking lot. One plaintiff who was suing an anesthesiologist because of alleged disabling back pain lost at trial because a juror observed her easily bending over to drink from a low water fountain.

Is the Patient Dehydrated?

Because dehydration is one of the leading causes of morbidity and mortality throughout the world, the hydration status of acutely ill patients, especially children, should always be assessed. Under general appearance, note sunken eyes or fontanelles, absence of tears, or dry mucous membranes. Specific signs are covered in Chapters 6, 7, and 18. Lack of adequate fluid intake is a chronic problem in many nursing home patients.

Is the Patient Malnourished?

In the US today, malnutrition is probably most common in infirm patients dependent on the care of others in understaffed nursing facilities. Check for loose-fitting clothing, complaints about dentures no longer fitting, mouth sores or loss of teeth, thinning hair, skin breakdown, and impaired wound healing. Do not overlook poor nutrition as a cause of confusion or mental deterioration.

Cleanliness and Grooming

An unkempt, unbathed patient may be very ill, emotionally disturbed, or in severe economic distress. Or he may be lacking in self-respect and respect for others. If dependent on others, his poor appearance may represent neglect by his caregivers. Pay special attention to the state of oral hygiene and the feet. Some patients are unable to see or reach their own feet.

Look for signs of identification with a particular subculture, such as piercings, tattoos, hairstyle, and mode of dress.

What does a woman's hairstyle, makeup, or manicure tell you about her self-image or socioeconomic status?

Figure 5-3 This clay figurine, over 2,000 years old, may represent the first reported case of tetanus in Mesoamerica. It shows severe opisthotonos and what seems to be a highly stylized risus sardonicus (sardonic grin) in an awake patient. The arms, however, are in the wrong position, as a patient suffering from tetanus would never be able to flex the upper extremities to the point of bringing the hands under the chin. Other observers have suggested that this piece of funeral statuary is an acrobat. This teaches us that what you see depends on what you are looking for. (Drawn from a figurine in the National Anthropological Museum in Mexico City.)

Self-study: Speculation

Without reading the legend, speculate on Fig. 5-3.

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CHAPTER

6

The Vital Signs

At this point it is necessary that you see a bullfight. If I were to describe one it would not be the one that you would see, since the bullfighters and the bulls are all different, and if I were to explain the possible variations as I went along the chapter would be interminable. There are two sorts of guidebooks: those that are read before and those that are to be read after and the ones that are to be read after the fact are bound to be incomprehensible to a certain extent before, if the fact is of enough importance in itself. So with any book on mountain skiing, sexual intercourse, wing shooting, or any other thing which it is impossible to make come true on paper, or at least impossible to attempt to make more than one version of at a time on paper, it being always an individual experience, there comes a place in the guidebook where you must say do not come back until you have skied, had sexual intercourse, shot quail or grouse, or been to the bullfight so that you will know what we are talking about. So from now on it is inferred that you have been to the bullfight.

—Ernest Hemingway, *Death in the Afternoon*

Points to Remember:

- Vital signs can provide a wealth of information pertaining to pathophysiology and diagnosis, as well as help to follow the course of an illness.
- The physician needs to be certain that equipment is calibrated and functioning properly, and that measurements are taken correctly and carefully. The physician must often make the measurements personally and utilize some special maneuvers.
- The physician should palpate, not simply count, the pulse.
- It is essential to check for the symmetry of pulse and blood pressure at baseline, and in any situation that could be a cardiovascular emergency, to avoid missing a dissection or a ruptured aneurysm.
- A "low" or "normal" blood pressure or temperature is not necessarily reassuring but can signify serious pathology.

Blood Pressure

History of Indirect Blood Pressure Measurement

The introduction of the sphygmomanometer is attributed to Potain, who is probably best remembered by cardiologists as the discoverer of cardiac gallops and best remembered by the literate as the great Parisian diagnostician in Marcel Proust's *Remembrance of Things Past*. Potain's pupil, Riva Rocci, invented the mercury manometer, which led to the dissemination of indirect sphygmomanometry for the systolic pressure and, once Korotkoff had discovered the sounds known by his name, for the diastolic as well. The latter story is a fable of medicine, well worth telling.

Korotkoff was a surgeon in the Czar's army, not an internist. He was doing experimental work on posttraumatic arteriovenous fistulas in the surgical dog. Pirogoff, his teacher (referred to in Dostoyevsky's *The Idiot*), had taught him always to auscultate over any area before performing an incision. On one occasion, while auscultating over an artery just as he was releasing a tourniquet, he heard thumping sounds! Abandoning his original scientific problem, he attempted to quantitate the amount of pressure required to make these auscultated sounds appear and disappear. He noticed that the sounds correlated with systole and diastole, as could be determined by direct inspection of the flow of blood from the distally severed artery of the dog.

It is worth noting that when Korotkoff first found these sounds in humans and reported his research, some thought him to be quite mad. At the very least, his auditors found his suggestion that the sounds originated from pressure changes in the artery to be unacceptable because they "knew" that all such sounds had to emanate from the heart. Korotkoff's response that the sounds could not come from the heart because they disappeared when the artery was completely occluded (Geddes et al., 1966) convinced no one, although apparently none of his critical professors had bothered to understand, let alone to replicate, his experiment. Returning to the panel of experts a second time, Korotkoff produced more evidence supporting the concept that the sounds came from the artery, not the heart, but the panel remained unconvinced (Segall, 1980). This story, a part of the oral tradition in which I was intellectually raised, was later confirmed by the written record (Multanovsky, 1970).

The final chapter of the story is unknown. Just as Lavoisier was guillotined during the French Revolution,[1] Korotkoff was said to have been arrested after the Russian Revolution. One version holds that he finally died during a Stalinist purge; another that he perished in 1920. As Stalin did not seize power until the late 1920s, this teaches us that history repeats itself and that historians repeat each other.

Blood Pressure Cuffs

Shortly after the dissemination of the blood pressure cuff, workers realized that some cuffs were of insufficient length or width to transmit the bladder pressure efficiently through the intervening tissues to the brachial artery (Geddes et al., 1966). Pioneer after pioneer increased either the length or the width of the bladder in this cuff. (The length is the dimension of the bladder that is

[1] The decapitation device named for Dr Joseph-Ignace Guillotin was neither invented nor christened by him. It was perfected by the Perpetual Secretary of the Academy of Surgery, Antoine Louis (Weiner, 1972).

wrapped around the arm.) Then, suddenly, the march of progress stopped short: short of a length or width sufficient to guarantee that arm circumferences greater than 27 cm would not generate spuriously hypertensive readings on occasion.

The above is the historic basis for the belief that one should use as long or as wide a blood pressure cuff bladder as possible. Dr Sapira recommended a thigh cuff; the scientific basis for this preference is reviewed later. This author finds a thigh cuff to be uncomfortable or painful for most patients and difficult to apply and inflate; she therefore prefers a large arm cuff for most patients.

According to the British Hypertension Society (BHS) guidelines, the bladder should encircle at least 80% of the arm's circumference (Markandu et al., 2000). The width of the cuff should be approximately equal to two thirds of the distance between the axilla and the antecubital space; a 12-cm wide cuff is adequate for most adults. Erroneously low readings may occur with a bladder that is too wide (Kaplan, 2002).

A Warning to the Neophyte

Many authors, when discussing the proper size of the bladder, refer to the blood pressure "cuff," when they really mean the bladder, which is inside the cuff. While the bladder, as a rule, has exactly the same width as the cloth covering (the cuff), the bladder is usually much shorter than the total cuff. Thus, *before purchasing* or making assumptions about a blood pressure cuff, one should inflate the bladder to see what its true dimensions are. (See the section entitled "The Fat Arm," later in this chapter.)

Maintaining the Equipment

As critical therapeutic decisions are based upon the blood pressure reading, it was shocking to discover that more than half of the mercury sphygmomanometers and their associated cuffs in a big London teaching hospital had serious problems that would have rendered them inaccurate (Markandu et al., 2000).

Be sure that the sphygmomanometer reading is zero when the cuff is not inflated. If you are using a mercury sphygmomanometer, be sure that the column of mercury is vertical. The mercury column should rise smoothly during cuff inflation and stop immediately when inflation stops.

The mercury should be a clean silver color; it oxidizes with time, forming a black powder. If a large amount of black powder has accumulated, the mercury needs to be removed and the column and reservoir cleaned. A method for doing so has been described (Yeats, 1992), although such instruments are likely to be retired, in these times when mercury encased in glass is of greater concern than that in vaccines injected into babies or in amalgams used in dental restorations.

If the mercury column is inadequately damped, or "bouncy," tighten the knurled nut at the top of the column (Reeves, 1995).

Calibrating the Manometer

For your black bag, you will probably purchase a sphygmomanometer with an aneroid pressure gauge. Be sure that it is a kind that does not have a pin stop, that is, a device that keeps the gauge from reading below zero when the cuff is deflated. The pin stop keeps you from being able to see that the gauge is out of calibration.

The aneroid gauge should be checked periodically, about every 6 months, for accuracy, preferably against a mercury sphygmomanometer. You will need a Y connector and tubing so that the bladder in your cuff can be simultaneously connected to both the mercury manometer and the aneroid gauge. Alternately, you can roll up two blood pressure cuffs together, inflate them partially, and squeeze them, checking their gauges against each other (whether one is a mercury manometer or both are aneroids). One survey found that 30% of aneroid instruments were off by 10 mm Hg or more, usually reading too low (Reeves, 1995). Another survey found inaccuracy in more than 50% of the aneroid manometers, with errors greater than 13 mm Hg in 7% (Mion and Pierin, 1998).

The aneroid gauge is a mechanical pressure transducer. The increase in pressure in the cuff causes an expansion of corrugated metal bellows, which drives the indicator needle through a series of gears. Repeated expansion of the bellows leads to a loss of elasticity, causing greater inaccuracy at high readings. Any trauma to the instrument can disrupt the gear system, causing inaccuracy at all pressure levels. Testing at two or three points does not exclude inaccuracy at other pressure levels (Bailey et al., 1991).

Automated Devices

The increased use of home blood pressure monitoring—as well as the sloppy techniques of clinicians that lead to inaccurate readings—has led to recommendations to use automatic devices with digital readouts. Such devices have been notorious for inaccuracy, and only a fraction of the hundreds of models available worldwide have been subjected to independent validation. There are two published standards for evaluating blood pressure devices: the American Association for the Advancement of Medical Instrumentation (AAMI) standard and that of the BHS. The devices currently available for self-measurement generally use an oscillometric technique, with an algorithmic method zealously guarded by manufacturers. Such techniques cannot measure blood pressure accurately in all situations, especially in the presence of arrhythmias. In some patients, they do not work for reasons that are not always apparent.

Of 30 tested devices, 28 did not meet the AAMI standard of a mean difference of less than 5 mm Hg from an intra-arterial measurement of systolic pressure, and 9 of 30 failed the standard for diastolic pressure. Additionally, 27 of 30 failed the AAMI requirement of a standard deviation of less than 8 mm Hg with regard to systolic pressure and 7 of 30 with regard to diastolic pressure (Van Egmond et al., 1993).

With monitors that passed AAMI and BHS validation criteria, more than half the patients tested may have average measurements that are in error by more than 5 mm Hg (Schwartz et al., 2003). Stiff arteries (Jones et al., 2003) and slow heart rates (Bendjelid, 2003) are additional sources of error.

Devices measuring blood pressure in the finger are not recommended because measurements may be distorted by peripheral vasoconstriction. Measurement at the wrist is also problematic. The upper arm devices are best. The usual advice concerning cuff size applies.

A physician who is going to rely on self-measurement by patients should have the patient bring the equipment to the office and demonstrate his technique. A mercury sphygmomanometer should be used to check the calibration. Be sure that the patient is placing

the cuff at the level of the heart on the arm with the higher blood pressure reading (*vide infra*). The diagnostic threshold may be different for home measurements, but data from longitudinal studies are lacking (O'Brien et al., 2001).

Making an Indirect Blood Pressure Measurement: A Method

There are two steps here: First, measuring the palpable systolic blood pressure, and second, the more customary auscultatory determination, also called the indirect determination of the systolic and diastolic pressures.

1. A blood pressure cuff of the appropriate size is wrapped snugly around the biceps. Be sure it is high enough so that your stethoscope bell can be applied right over the brachial artery (Fig. 6-1). (There is no evidence that putting the stethoscope under the cuff, as is done with many automatic devices, gives a spurious reading.) To ensure this, you might wish to locate the brachial artery by palpation and mark it with a chalk or a washable ink. (Be sure to ask the patient's permission to mark the arm.) Doing this the first dozen times is a good beginner's practice, as it may prevent your placing the cuff too low on the biceps. In that case, you would have to remove and reapply it between the determinations of the palpable and auscultatory systolic pressure.

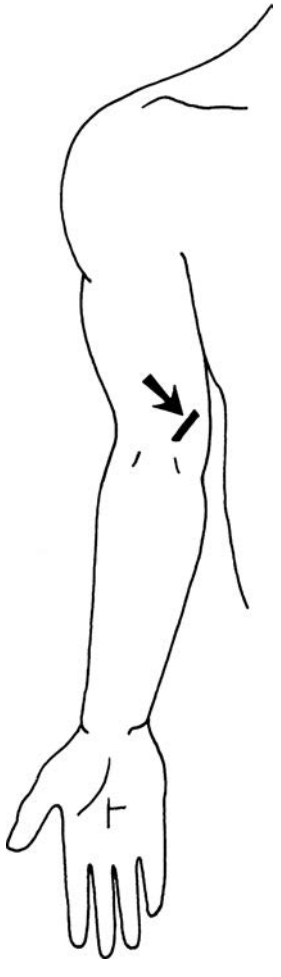

Figure 6-1 Location of the brachial artery.

2. Now look at the mark. Is it level with the patient's heart? If the patient is lying down, it probably is, unless you have allowed the arm to hang over the edge of the bed. In that instance, you would get a falsely elevated value because the height of the blood column between the heart and the brachial artery would be added to the actual pressure inside the vasculature.

   If the patient is sitting with his arm resting on your desk, the marked brachial artery will probably not be beneath the level of the heart, but it might well be above that level. This could produce a falsely *decreased* blood pressure measurement because the pressure generated during systole is partly expended in climbing the vertical distance up the arterial tree to the brachial artery where you are making your measurements (Mitchell et al., 1964).

   For each centimeter that the center of the cuff is above the heart level, the reading will be about 0.8 mm Hg too low. It will be a comparable amount too high if the cuff is below the heart level. Use adjustable chairs, cushions, or phone books to place the arm at the proper height (Grim and Grim, 2008).

   Please remember these simple plumbing rules, as they are the basis for understanding several artifacts and caveats to be presented later.
3. Be sure that the blood pressure cuff is not applied over clothing. The addition of a layer of anything increases the diameter of the arm and also increases the chance for "slippage," that is, lateral displacement of the pressure generated by the cuff. In fact, the presence of clothing is similar to the model used for studying "cuff hypertension," another form of spuriously elevated blood pressure. As with the arm position, the addition of a layer of thin clothing *usually has a small* effect on the blood pressure, but why introduce any indeterminate variable into your measurements if it is so easily avoided?
4. Notice that the pressure bulb has a screw valve that can be manipulated by the thumb and fingers with the bulb resting in the palm of your hand. Try screwing the valve into each of its two extreme positions. In one of these extreme positions, the air you squeeze from the bulb will go into the cuff and not come out. In the other extreme position, any air pumped into the cuff will immediately come out when you stop pumping. If neither position allows all the air to be retained, there must be a loose connection or a leak somewhere in the system.

   To inflate the cuff, turn the screw valve to the position that allows all the air to be retained. The cuff should be inflated rapidly because slow inflation traps venous blood in the arm and may result in pain and distorted or diminished sounds (Grim and Grim, 2008). To deflate the cuff, turn the screw valve *very slightly* so that the pressure drops at the rate of 2 to 4 mm Hg per second. A slower rate may cause falsely high readings, but remember that the accuracy can be no greater than the rate of deflation (Kaplan, 2002). There are situations, such as the determination of pulsus paradoxus, in which the rate of deflation must be as slow as 1 mm Hg per second.
5. Put your right hand on the sphygmomanometer bulb and your left hand where you can feel either the brachial artery distal to the cuff or the radial artery. This is for the purpose of determining the systolic pressure by palpation. Pump the pressure in the cuff as high as you need to in order to make

the pulse disappear. Then, slowly lower the pressure to see at what point the pulse returns. That point (expressed in mm Hg read from the manometer dial) is the systolic blood pressure "by palpation." Usually, this is not recorded unless it is not possible to obtain the systolic pressure by auscultation. In such a circumstance, both the positive and the negative findings may be noted (e.g., "BP not auscultable; systolic 90 by palpation").

6. Lower the pressure all the way to zero and pick up your stethoscope. The use of the stethoscope is discussed in more detail in Chapters 16 and 17. At this point, you need to know only the following: (a) the earpieces are to be placed in your ears so that they point slightly forward; otherwise, depending on the anatomy of your ear canals, you may not be able to hear anything at all; (b) the earpieces should not hurt your ears; if they do, you must replace them as soon as possible with a style that fits comfortably; and (c) the bell should be used for taking the blood pressure. Tap or breathe alternately on the bell and the diaphragm to see which one is "online." Switch from one to the other either by pressing a lever or by rotating the head, depending on the model of your stethoscope. Although the diaphragm is usually satisfactory for taking the blood pressure, the bell is preferable for hearing the low-pitched Korotkoff sounds, especially when they are faint. Of course, if you press heavily with the bell (as evidenced by the circular indentation left in the skin), it is converted into a diaphragm.
7. Place the bell of the stethoscope lightly over the brachial artery but in contact with the skin over its entire circumference.
8. With your other hand, pump up the cuff as before, quickly going about 10 mm above the systolic pressure, as determined by palpation. Gradually lower the pressure as described above. The point at which you hear the Korotkoff sounds appear is the systolic pressure by auscultation.
9. Continue deflating the pressure until the sounds disappear. That is the diastolic pressure. If you were lowering the pressure too fast to determine the exact point of the diastolic pressure, deflate the cuff, allow the veins to drain (so as to avoid producing an auscultatory gap), and again pump the cuff up to just above the "guesstimated" diastolic pressure to obtain an exact measurement. Listen while the cuff is deflated slowly at least 10 mm below the diastolic pressure to ensure that no further sounds are heard, and then deflate the cuff quickly.
10. If you happened to notice a point at which the sounds became muffled, record that also. If you did not notice the muffling, it is probably not worthwhile to go back and find it. As we shall see, it is probably not a useful number under ordinary circumstances. In addition, many normal people do not have a point of muffling.

Sometimes, in high output states with vasodilatation, the sounds do not disappear until the cuff is fully deflated. In this case, you would record the blood pressure as K1/K4/0 (where K1 or the first Korotkoff sound is the systolic pressure, K4 is the point of muffling if heard) or K1/0 (Grim and Grim, 2008).

The American Heart Association recommends taking a second reading after the patient has rested for at least 30 seconds and averaging the two (American Heart Association, 1980).

If the Korotkoff sounds are very faint, you may have the patient, wearing the cuff, raise his arm and open and close his fist several times. Then, inflate the cuff; lower the arm with further inflation, if needed; and listen again (Reeves, 1995).

It is possible to measure both systolic and diastolic pressures by palpation. The procedure was independently discovered by Ehret in 1909 and by Segall in 1940 (Enselberg, 1961). In Segall's original study (Segall, 1940), using *light* palpation over the vessel to sense the Korotkoff vibrations, it was possible to get values within 10 mm of the auscultatory measurements of both systolic and diastolic pressures in all 100 subjects. In more than half the cases, there was no difference between the pressures as determined by palpation versus auscultation.

If you place your thumb lightly over the brachial artery, you should be able to feel the "sharp" (phase 4) Korotkoff sounds as sharp knocks a little before the diastolic pressure reading. After a slight increase in sharpness, they suddenly disappear, and then the normal brachial pulse can be felt. The disappearance of knocks was found to have an excellent correlation with the diastolic pressure determined by auscultation (correlation coefficient 0.99) in 50 adult inpatients (Vaidya and Vaidya, 1996).

Variability of Blood Pressure

There is really no such thing as *the* blood pressure. A person's blood pressure varies throughout the day. Try the following as a self-study:

1. Go to the library and consult one of the better texts on hypertension, such as Kaplan's *Clinical Hypertension*. Read the portions indexed under "variation," "variability," or "diurnal variation" and the summarized literature. Has anyone ever made multiple measurements of *the* blood pressure and found the blood pressure, or has everyone who has made multiple measurements found variability to be the rule?
2. Take your partner's blood pressure, and then have him take yours. Repeat several times. Do the pressures change or stay the same?
3. Let your partner be at complete rest and take his pressure several times, until sequential readings are within 5 mm Hg of the last reading (systolic and/or diastolic). Now, simply leave the room and return immediately to make another measurement. Or by prearranged signal, have someone else enter the room while you are making a measurement. What happens to the blood pressure? Alternatively, do not tell your partner one of the readings, but look at him with astonishment, and quickly begin to measure the pressure again. What happens to the pressure?
4. Go on to the wards and pick up a chart containing blood pressure determinations made (by the nurses) more than once a day. Are they ever the same? How often are they the same?
5. Go to the intensive care unit where a patient is at complete rest and has a continuously reading intra-arterial blood pressure monitor. Pick a patient whose medication is not being changed. Write down the displayed blood pressure every 10 seconds. How many are the same? How many are different? How many of the patients are like this?
6. Which of the above maneuvers showed the greatest variability, and which showed the least variability? Did you calculate the standard deviations?

Check the effect of various substances on the blood pressure. Smoking tobacco is said to increase systolic blood pressure by 20 mm Hg within 4 minutes (Kaplan, 2001). What is the effect of alcohol or caffeine? A number of widely used drugs may increase blood pressure (Kauffman, 2006), including COX-2 inhibitors, antimigraine drugs, anti-incontinence drugs, nonsteroidal anti-inflammatories (Gurwitz et al., 1994), oral contraceptives, cold remedies, cyclosporin, and tricyclic antidepressants (Joint National Committee, 1988).

What Is High Blood Pressure?

In the 1970s, the upper limit for resting blood pressure was 160/95 mm Hg. Like "acceptable" cholesterol levels, blood pressure goals have been migrating downward. According to one major cardiology textbook (Black et al., 2001), the upper limit of acceptable in 2001 was 140/90, which corresponds to a home measurement of about 133/84. Still lower levels are, however, considered desirable. The "optimal" level of 120/80 mm Hg or less is actually observed in only 25% of adult men for systolic pressure and in 36% for diastolic pressure (Kaplan, 2001).

Using actual death rates from the Framingham study (Port et al., 2000a), rather than values derived by a computer curve-fitting algorithm, one can deduce that serious risk elevation begins at 165 mm systolic pressure if one is conservative and at 185 mm if one is not (Kauffman, 2006). Blood pressure rises with age, and hypertension is less damaging in women. Port et al. give treatment thresholds by age that are much higher than those recommended by official sources in 2004, such as the Health Services Advisory Group (HSAG), while warning that risk rises more rapidly with pressure than previously thought for persons in the upper 20% of pressures for their age and sex, indicating the need for more aggressive treatment (Port et al., 2000b). HSAG, by contrast, set a target of 75% of patients having their most recent blood pressure below 130/80, regardless of age. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure calls blood pressures between 120 and 139 systolic or 80 to 89 mm Hg diastolic "prehypertensive" (Chobanian et al., 2003).

While treatment standards may vary, one constant remains: the need to measure blood pressure frequently and accurately.

Determining Diastolic Pressure

There has long been a controversy as to whether the muffling or the disappearance of the Korotkoff sounds should be used as the diastolic pressure. The first committee of the American Heart Association recommended that the fourth phase (muffling) of the Korotkoff sounds be adopted as the correct locus for diastolic pressure. In 1959, a second committee recommended that it be the fifth phase (disappearance). In 1967, a third committee switched back to recommending the muffling (fourth phase), but the published recommendation included an appendix stating why disappearance (fifth phase) was superior! In fact, one of the members of that committee used disappearance for determining the diastolic blood pressure in the famous Veterans Administration Cooperative Study. The next committee recommended using disappearance in adults and muffling in children. However, a Finnish study showed that the fourth phase sounds were absent in between 3% and 6% of children aged 6 to 18 years (Uhari et al., 1991). A Dutch study showed that the fourth sound could not be detected at all in 23% of pregnant women and, if present, could not be precisely measured ($\kappa = 0.42$ for the fourth sound and $\kappa = 0.96$ for the fifth sound) (Franx et al., 1998). It should be clear even to the casual observer that expert committees are not necessarily correct.

A thorough review of the literature clearly indicates to me that in most persons, the disappearance of the sounds should be used for the diastolic pressure (*vide infra*). The various drug studies proving the value of antihypertensive therapy have all used diastolic pressures determined by disappearance.

Admittedly, there are situations of high stroke volume in which the disappearance gives an artifactually low pressure, sometimes even an impossible 0 mm Hg. (Apparently, in such cases, the artery continues to return toward baseline throughout diastole.) Examples include severe aortic insufficiency; patent ductus arteriosus; and high-output cardiac failure, as in pregnancy, fever, anemia, thyrotoxic heart disease, and beriberi. If you suspect one of these entities, you should follow the American Heart Association's current recommendation of recording all three pressures (i.e., systolic, muffling, and disappearance, e.g., 140/80/0). But which one should be "used"?

In aortic insufficiency, at least, we know that muffling best approximates the directly measured intra-arterial pressure when the indirect diastolic blood pressure is "zero" (Goldstein and Killip, 1962). As muffling was only 2 mm different from the directly measured pressure, we may assume that in other situations with an impossible "zero" diastolic pressure, muffling should also be used as the diastolic pressure.

The muffle point may also be used for the diastolic pressure in severe bradycardia in which the disappearance point may be nearly zero, although the high stroke volume is not accompanied by a high cardiac output (Goldstein and Killip, 1962).

I had originally intended to write an entire chapter on the confusion about the indirectly determined diastolic blood pressure, not only to clarify and convince, but also to show how the history of the subject is an example of how fuzzy thinking and sloppy scholarship can confound such a common activity. However, intra-arterial lines are now so ubiquitous that the student is advised to measure indirect blood pressures on such monitored patients and convince himself of the truth. Accordingly, I will simply cite a few examples of well-done experiments that demonstrate disappearance to be closer to the true diastolic pressure than muffling, except in situations of high stroke volume (Karvonen et al., 1964; London and London, 1967; Raftery and Ward, 1968).

The Fat Arm

The standard adult blood pressure cuff has a bladder of the correct size for arms whose brachial circumference is up to 27 cm. If the circumference is greater than 27 cm, the larger the arm, the greater the overestimation of both systolic and diastolic pressures if the indirect blood pressure is performed with a standard cuff (King, 1967). The pharmacologic treatment of normotensive patients who have "cuff hypertension" may actually increase their mortality (Kaplan, 1983).

Some authors have attempted to apply epidemiologic formulas to correct the systolic and diastolic pressures in patients with large

arms (Pickering et al., 1954). The epidemiologic corrections were derived from the experimental data (Ragan and Bordley, 1941), which were faulted in several ways, according to the original report. In any event, the correction factors are invalid in individual patients because of variability in pulse wave contour, radius of the brachial artery, brachial artery to biceps ratio, and so forth, all of which affect the exact degree of blood pressure overestimation from an undersized cuff.

Some workers (Devetski, 1963) have suggested wrapping the arm cuff around the forearm and taking the blood pressure at the radial artery, with the arm in a supinated position. (The mean arterial blood pressure at the radial artery is from 3 to 5 mm less than at the brachial.) My own preference is to obtain a very large cuff. One can use either a very wide (20 cm) cuff such as a thigh cuff or a very long (42 cm) bladdered cuff (King, 1967). Despite statements to the contrary, I know of no good evidence that the use of a large cuff in an adult can produce a spuriously low blood pressure. In fact, there is evidence to the contrary (Karvonen et al., 1964; King, 1967; Linfors et al., 1984; Montfrans et al., 1987; Nielsen and Janniche, 1974).

For the Attending. As a teaching exercise, pick a medical student with large biceps and take his blood pressure. Then, take some foam rubber padding, about 1 in. thick, and wrap it around the upper extremity to imitate the mechanical effect of fat. (Alternately, use a few Turkish towels, a lab coat, or any pliable material that resembles normal fat by being compressible.) Note that you have not actually altered the subject's cardiovascular system. Place your blood pressure cuff around the foam rubber "fat" and take the blood pressure again. Remove the "fat" and take the blood pressure yet again. What is the effect of increasing the upper arm circumference on the indirectly determined blood pressure?

Admittedly, obesity tends to increase the blood pressure even beyond the effect of circumference. However, here we are concerned only with the effect of arm circumference on the accuracy of the indirectly determined blood pressure.

Many clinicians have very sharp cutoff points above which they treat the blood pressure and below which they do not. You can estimate from this experiment that a large number of people with fat arms are being treated for a disease, essential hypertension, which they in fact do not have.

Essential Hypertension

I regretfully use the word "essential" to modify the noun "hypertension" for convenience in communicating. Along with Sir George Pickering, I do not believe that hypertension is a disease *sui generis*. However, if it is, I do not see how it can be "essential."

Back at the turn of the century, arterial occlusive disease could only be diagnosed at autopsy. As some of these patients were found to have elevated blood pressures, as determined by the newly popular sphygmomanometer, some prestigious authorities hypothesized that the hypertension was secondary to the diffuse arterial occlusive disease and that it was an adaptive response, "essential" in that it provided a high head of pressure for driving the blood through the stenotic vessels. The ghost of this disproven hypothesis lingers among those who fear that lowering the blood pressure in malignant hypertension will deprive vital organs of blood flow.

As various specific etiologies of hypertensive states were discovered, the adjective "essential" came to refer to those forms of hypertension of unknown etiology, or more than 90% of cases. It should be distinguished from hypertension of unexamined etiology.

When this author was in medical school, considerable emphasis was placed on ruling out treatable causes of hypertension before consigning a patient to the "essential" category. These days, a minimal workup is recommended before starting therapy, but "more extensive testing for identifiable causes is not indicated generally unless BP control is not achieved" (Chobanian et al., 2003).

Oddly, the new adjectival meaning of "essential" has metastasized to a variety of other conditions. For instance, one reads of an entity called "essential migraine," although one is hard pressed to explain to the migrainous patient exactly what is essential about his suffering. (Migraine itself is a useful word only if you know that it is derived from "hemicrania." It then becomes a diagnosis that suggests itself when evaluating a patient with unilateral cephalalgia.)

A Note to the Sophomore

Have you noticed how the text is changing? Words and concepts that you have not previously encountered are starting to spring up. The material is no longer oriented to the layperson. If you are a sophomore reading this in sequence, you are confronted with a problem that will continue for the next few years: what to do when you are no longer sure that you understand all the words. My advice is to stop and look up the strange words in a medical dictionary or textbook. Remember this is not a textbook of medicine. This is similar to a book on how to sail your boat; you still have to buy some charts in order to set your course.

On the wards, you will also hear residents and staff using words and phrases that you do not know. You can raise your apparent IQ by 10 points simply by carrying with you at all times a small notebook for recording all the strange words of the workday. Each night look up all the words you collected during the day.

The Individualized Approach to Patients with Hypertension

The patient diagnosed with hypertension will be expected to have far more interaction with the medical system than he probably would like and might be expected to take expensive medication with troublesome side effects. Results are likely to be much better if the physician strives for *concordance* (see Chapter 2) rather than *compliance*.

The higher the patient's blood pressure, the larger the benefits that the treatment offers him. For more moderate hypertension, the benefits of treatment are long-term and possibly detectable only over a large population. In selecting treatment goals with the patient, the physician should keep the effect of age and sex differences in mind, as well as the evidence in the literature concerning *all-cause mortality*, not just surrogate endpoints such as population-based blood pressure targets.

Although it is clear that hypertension is a risk factor for (i.e., is correlated with) cardiovascular disease, remember that it is a sign, not a disease (*vide supra*). While secondary hypertension may be uncommon, keep the possibilities in mind while performing

your history and physical examination, or you will miss them. The possibilities include endocrine disorders (such as pheochromocytoma or adrenocortical hyperfunction) or renal disease (including renovascular stenosis, see Chapter 18). Severe hypertension has even been described in a 9-year-old girl in association with signs of scurvy (see Chapter 7); all signs, including the hypertension, resolved with treatment with vitamin C (Weinstein et al., 2001). Be aware of possibly contributory factors such as obstructive sleep apnea (see Chapters 13 and 14) and hyperinsulinemia secondary to diet and obesity. If a patient becomes nonresponsive to a previously effective regimen, look for a supervening cause such as renovascular disease.

Even for "essential" hypertension, the mechanisms in the individual patient should be considered in prescribing therapy. Blood pressure is a function of cardiac output and peripheral resistance. If cardiac output rises to compensate for anemia, fever, beriberi, aortic valve defects, hyperthyroidism, or stiff arteries, the systolic pressure rises. Peripheral resistance is inversely proportional to the fourth power of the internal radius of the blood vessels (see Chapter 18), so tiny decreases in the lumen by atherosclerotic plaques will have a large effect on blood pressure.

Laragh distinguishes V-type (low renin) and R-type (high renin) hypertension. In the former, sodium retention and expanded plasma volume support increased cardiac output. In the latter, total peripheral resistance, set by the renin–angiotensin system, is high. V-type hypertension, predominantly found in black patients, responds well to sodium restriction and diuretics. R-type hypertension responds to beta-blockers and angiotensin converting enzyme inhibitors (Laragh, 2001). The history of previous response to various drugs is extremely important for choosing therapy that is effective and safe, especially if the patient presents with hypertensive crisis (*vide infra*) (Blumenfeld and Laragh, 2001).

In the current fad for uniform ("one size fits all") treatment protocols, dietary sodium restriction is recommended for everyone—despite the fact that blood pressure is salt sensitive in only a subset of hypertensives and that the average decrease in systolic blood pressure 13 to 60 months after the initiation of salt restriction in 11 long-term randomized controlled trials was only 1.1 mm Hg (Hooper, 2002). The poor results might be explained by poor compliance and the natural history of hypertension, which tends to increase with time (T. Fagan, *personal communication*, 2009). Your patient may be in the 20% to 30% with low-renin hypertension who respond well to salt restriction; in the minority whose blood pressures may actually increase; or in the majority for whom this onerous intervention makes little difference.

Supervised home blood pressure monitoring, which can closely follow the effects of various habits, drugs, or interventions, helps to make the patient your ally. Always remember that your patient is Mrs Jones, not her blood pressure chart.

Where to Measure Blood Pressure

Upper Extremities

Begin by taking the blood pressure in both upper extremities. This is usually done at the right and left brachial arteries. The difference in the systolic blood pressure between the two arms can result from any intrinsic abnormality present in at least one arm, *plus* the amount of neurovasomotor change (either excitement or relaxation) that has occurred as you move from one extremity to the other. Such change will affect both systolic and diastolic pressures. Any significant intrinsic vascular obstruction will cause a difference of at least 10 or 15 mm in the systolic pressures. To be sure that a significant difference is present requires two observers to measure at the same time and then switch sides to remeasure. Dr Alvin Shapiro of Pennsylvania reports, "I have 'ruled out' coarctation and subclavian steals 'detected' by house officers and students by using this maneuver at the bedside, on many occasions."

Once you have determined that both arms have the same blood pressure, you usually need to take the pressure in only one arm. If the pressures are unequal, the arm with the *lower* pressure is the abnormal one, most often because of an obstruction due to atherosclerosis (see, for example, "Subclavian Steal Syndrome," Chapter 18) or, more rarely, from a dissecting aneurysm.

Lower Extremities

With the patient recumbent, take a lower extremity *systolic* blood pressure, by palpation or auscultation, over the popliteal artery (using a thigh cuff) or the dorsalis pedis (placing a cuff around the calf). The difference between the arm and leg systolic pressures results from any change in neurovasomotor tone occurring between the two measurements plus any intrinsic abnormality. Note that *paired leg and arm pressures must both be taken with the patient recumbent*. Never take a lower extremity blood pressure with the patient sitting or standing because the height of the blood column between the artery and the heart would add to the blood pressure and confound your data.

Brachial-Popliteal or Brachial-Dorsalis Pedis Systolic Pressure Gradients

Normally, the *indirect* systolic blood pressure can be *up* to 10 mm Hg *higher* in the lower than in the upper extremity in the absence of any structural abnormality. The difference may even be as great as 20 mm Hg (Frank et al., 1965; Sapira, 1981). However, *direct* intra-arterial measurements reveal that the systolic and diastolic pressures, as well as the mean pressures, are normally the same in upper and lower extremities (Pascarelli and Bertrand, 1964).

The systolic blood pressure in the lower extremity is found to be *significantly less (at least* 6 mm Hg) than in the upper extremity in cases of obstruction in the vascular tree. The most common cause of obstruction in the elderly Westerner is atherosclerosis (see also Chapter 18). The most common cause in the young hypertensive is coarctation of the aorta (see Chapter 18).

An ankle/arm blood pressure index of less than 0.9, because of its correlation with peripheral vascular disease, is associated with a higher risk of coronary heart disease and greater all-cause mortality. The respective adjusted relative risks (RRs) were 3.7 and 3.1 in one study (Vogt et al., 1993) and 3.2 and 3.8 in another (Newman et al., 1993). By contrast, a high total cholesterol level in women confers a RR of coronary heart disease of only 1.1 (Applegate, 1993). (This ratio is also called the *ankle–brachial systolic pressure index* or ABI [see Chapter 18].) Measuring the ABI with a hand-held Doppler has been recommended as a routine screening tool in primary-care practices (Ankle Brachial Index Collaboration, 2008).

The systolic blood pressure in the lower extremities is significantly *higher* than in the upper extremities in patients with occlusion of the upper extremity vasculature, as in Takayasu disease, Buerger disease, or other selective disease of the upper extremities; in some cases of dissecting aneurysm; and in conditions of high stroke volume (the Hill sign). In the Hill sign, especially because of aortic insufficiency, the indirect lower extremity systolic pressure may be 20 to 60 mm Hg higher than that in the upper extremity. (The mechanism for the Hill sign is given in Chapter 17.)

Once you have the recumbent blood pressures recorded in all four limbs, you have a perfect baseline for the later detection of dissecting aortic aneurysm. Depending on the location of the dissection, any one or more of the extremities might have a damped arterial pulse wave. In fact, suspicion of this life-threatening disease is the one situation in which you *must recheck* all four extremity blood pressures in the recumbent position. Failure to note the significance of an undetectable blood pressure in one arm, in a patient with a "clear" picture of myocardial infarction, has resulted in a delayed diagnosis of dissecting aneurysm, possibly contributing to his death (Jauhar, 2006).

Postural Hypotension

Postural hypotension refers to hypotension in the erect position relative to the recumbent position. The two main causes are volume depletion (due to anything from gastrointestinal hemorrhage to adrenal cortical insufficiency to diuretics) and neurogenic factors (e.g., due to certain antihypertensive medications; the various forms of autonomic vasomotor dysfunction; or even prolonged bed rest or weightlessness, as with the original astronauts). Less common causes include heart failure (the heart being unable to increase output when the patient stands) and pheochromocytoma (a rare disease in which hypovolemia compounds the problem caused by down-regulation of the noradrenergic receptors).

A Method

Take the systolic and diastolic blood pressures in an upper extremity with the patient recumbent. Have the patient stand and immediately repeat the measurement, with his arm by his side. Normally, the diastolic pressure remains the same or rises slightly and the systolic pressure stays the same or drops slightly. The calculated *mean* arterial *blood pressure* [$BP_{mean} = BP_{dias} + 0.4\ (BP_{sys} - BP_{dias})$] does not normally drop more than a few mm Hg on standing. Note that the normal diastolic pressure almost never drops, and when it does, the drop is slight and the systolic pressure will rise. Conversely, many normal persons experience a drop in their systolic pressure on standing, but their diastolic pressure rises so that the mean arterial pressure is maintained.

As a teaching exercise, take your partner's blood pressure and pulse while he is recumbent and then while he is in the erect position. Calculate the mean arterial blood pressure changes (if any) with orthostasis. Have your partner repeat the exercise on you.

Some authorities recommend multiplying the pulse pressure ($BP_{sys} - BP_{dias}$) by one third or one half. I use 0.4 as my correction factor because that yields values that most closely correlate with simultaneous *direct* mean arterial blood pressure measurements. In actual practice, for assessing postural hypotension, any of the formulas may be used.

If the patient has postural hypotension, do not forget to check the pulse simultaneously. Failure of the pulse rate to rise in response to an orthostatic drop in pressure is a valuable clue that the problem is neurogenic and not due to volume depletion. However, alpha-blockers can prevent the orthostatic pulse increase despite the presence of volume depletion. The presence of an *increase* in pulse tells you nothing; some neurologic lesions impair the pressor response without preventing a rise in the pulse rate. Also, some patients (e.g., some diabetics, patients with Wernicke encephalopathy, and recipients of cardiac transplants) have a predominant vagal insufficiency so that the pulse is always high.

Sometimes you will attempt to find postural hypotension in a patient who is too ill to stand by himself. In that case, the blood pressure may be taken in the sitting position and compared with that in the recumbent position. (Try, if possible, to get the legs in a dependent position to promote blood pooling in the lower extremities.)

If it is difficult to obtain the standing blood pressure because you are moving too slowly owing to inexperience, try pumping up the blood pressure cuff to a point just above the recumbent systolic pressure immediately before having the patient stand. The same maneuver can be used for the diastolic pressure. However, you must still move quickly because pain, including that produced by an inflated blood pressure cuff, can act as a pressor stimulus.

Tilt Tables

If you have access to a tilt table, you can use it to obtain orthostatic pressures in a patient who is very ill. Simply strap the patient in with his feet against the footboard, measure the blood pressure with the patient in the horizontal position, and tilt him to the erect position for the second blood pressure measurement. Remember that normal persons may have an initial orthostasis if passively tilted in such a way that they *cannot* use their leg muscles for standing or that weak persons may have orthostasis if they do not contract their leg muscles (because muscle contraction increases venous return). That is why the patient should be observed, to ensure that his feet are positioned properly against the footboard and that he is using his legs.

A tilt table can be used to detect susceptibility to a vasovagal reaction in patients who have unexplained syncope. Such a reaction may be the most common cause of loss of consciousness; it does not always cause premonitory signs and symptoms. After 10 minutes in the supine position, patients are tilted up to 60 degrees for 60 minutes or until symptoms are reproduced. A vasodepressor response is defined as a 60% or greater decrease in systolic blood pressure. Patients with a vasovagal response have an accompanying decrease in heart rate (by 30% of the supine rate or to fewer than 45 beats per minute). In a study of 54 patients who had had extensive investigation without getting a diagnosis, 50% had an abnormal response to the tilt test (Raviele et al., 1991).

Sensitivity and Specificity

In phlebotomy, an orthostatic rise in the pulse rate of 30 per minute *or* light-headedness sufficiently severe to cause the patient to lie down or experience syncope was associated with the loss of 1,000 mL. The sensitivity was 98%, and the specificity was 98%. However, the test did not work for a 500-mL blood loss or if the subject only sat up instead of standing (Knopp et al., 1980). Using

a tilt table, the cutoff was 25 per minute regardless of symptoms, with 100% sensitivity and specificity (Green and Metheny, 1948).

A Caveat

If you already know that the patient is volume depleted or in shock, you might *not* want to perform the testing for postural hypotension. There are two reasons for this.

The first reason is derived from one of the first rules of medicine: *primum non nocere* (variously translated as "first, do no harm" or "whatever you do, don't make things worse, even if it means doing nothing very much"). If the patient is hypotensive to the point of having marginal perfusion to some of his tissues, standing him up might do temporary or permanent harm by decreasing perfusion further. It is rare for a patient in shock to have a stroke because he was tilted up, but it is impossible to predict which patient that might be.

The second reason is that any risk of harm must be justified by an expected benefit. If one already knows the patient to be in shock, adducing more evidence in favor of the diagnosis is wasteful at best. Initially, treatment can be titrated against blood pressure, pulse rate, urine output, and so forth, until these are normalized. At that point, one can more safely switch to more sensitive measures of homeostasis, such as orthostatic hypotension.

Delayed Orthostatic Readings

To improve the specificity of the postural hypotension test for *extreme* conditions of volume depletion or neurogenic orthostatic hypotension, some speakers have recommended keeping the patient in an erect position for 5, 10, or 15 minutes and continuing to measure the blood pressure. It has been stated, in the absence of any data (so far, I am not aware of any such data) and contrary to my experience, that those individuals who are able to compensate by the end of 10 or 15 minutes are experiencing neurogenic orthostatic hypotension and specifically do not have volume depletion.

The absence of normal values is one source of confusion. An additional problem is a modification that certain young clinicians have made: omitting the initial measurement on standing, when the patient's symptoms are at a maximum. I have seen *both false positives and false negatives* with this latter technique and therefore strongly warn against it. Because there is no such thing as "the" blood pressure (the mean arterial pressure varies over the course of the day), there is a 50% chance that the blood pressure measured 15 minutes later will be lower than the baseline pressure, even if there was no initial orthostatic drop (a false positive). The false negatives occur in individuals with milder degrees of volume depletion, who increase cardiac output by increasing venous return through "walking in place." Also, the noxious subjective experience of the initial (but unmeasured) orthostatic hypotension stimulates the autonomic nervous system. For these reasons, many persons are able to compensate, and even overcompensate, for orthostasis after 10 to 15 minutes of standing.

Blood Pressure in Atrial Fibrillation

The blood pressure depends on cardiac output and peripheral resistance, and the cardiac output, in turn, depends on stroke volume and heart rate. As indirect blood pressure determinations are made on a beat-by-beat basis, anything that changes the stroke volume from beat to beat will alter the blood pressure measurement. Although we willingly take advantage of this phenomenon when measuring pulsus paradoxus (*vide infra*), we tend blithely to ignore it in the case of atrial fibrillation.

An isolated indirect blood pressure reading is completely unreliable in a patient who has atrial fibrillation with irregular ventricular responses and highly variable RR intervals. As a short RR interval permits a minimal amount of ventricular filling, the stroke volume will be quite low at the time of the next ventricular contraction, and hence, the indirectly measured blood pressure (systolic and diastolic) will be low. Conversely, when the RR interval is extremely prolonged, the ventricular filling will be great, and the apparent systolic (and diastolic) pressures will be quite high. Thus, although rough estimations of the general range of blood pressure can be made during atrial fibrillation, the more exact measurements needed for diagnosis and therapy of high or low blood pressure must await more regular RR intervals. Of course, the same is true for all other arrhythmias in which there are wide variations in RR intervals.

What should the practitioner do? I suggest averaging the three blood pressures obtained in the following manner:

1. Drop the cuff pressure *very slowly* until you can hear three beats in a row (i.e., three beats with a *relatively* constant RR interval). The pressure at the first beat is the systolic.
2. After having previously "guesstimated" what the diastolic pressure might be, quickly drop down to about 10 mm Hg above that value, and then lower the pressure very slowly. Whenever you last find three audible beats in a row, the diastolic pressure is obtained from the last beat you heard.

This method is not scientifically validated and would no doubt produce different results than a "two-in-a-row" method. Different observers will get different pressures, not only because of sampling differences but also because they will decompress the cuff at different rates. Thus, although this is a fairly good adaptation of the indirect blood pressure method for measuring changes in a given individual, it is not as good for measuring the exact, absolute diastolic pressure, an important issue for those who believe that a diastolic pressure of 90 mm Hg requires lifelong treatment, whereas one of 89 mm Hg does not.

Arthur Mirsky used to tell me that there were no brittle diabetics, only brittle physicians. Maybe atrial fibrillation is God's way of making some hypertensionologists less brittle and more humble.

Blood Pressure in Ventricular Tachycardia

In ventricular tachycardia with atrioventricular dissociation, there is irregular ventricular filling and hence irregular stroke volume, depending on the chance position of the atrial contraction in relationship to the ventricular contraction. Thus, the first Korotkoff sound may be irregularly heard at a higher pressure than that at which the sound is heard with every beat. This finding may help distinguish the rhythm from a supraventricular tachycardia (Wilson et al., 1964).

Disorders Associated with Hypertensive Crisis

Hypertensive crises account for a significant number of admissions to a medical emergency department. Examples include hypertensive encephalopathy, intracranial hemorrhage, unstable

angina pectoris, acute myocardial infarction, acute left ventricular failure with pulmonary edema, dissecting aortic aneurysm, and preeclampsia/eclampsia. Traditional management strategies hinge solely on rapid blood pressure reduction, but this strategy can be detrimental; thus, consideration of pathophysiology is important in planning treatment (Blumenfeld and Laragh, 2001).

More than 80% of patients presenting with acute ischemic stroke have elevated blood pressures, which generally decline toward prestroke levels within 4 days without treatment. It is important to remember the role of autoregulation of cerebral blood flow in maintaining cerebral perfusion pressure:

$$\begin{aligned} \text{CBF} &= \text{CPP}/\text{CVR} \\ &= (\text{mean arterial pressure} - \text{venous pressure})/\text{CVR} \end{aligned}$$

where CBF is the cerebral blood flow, CPP the cerebral perfusion pressure, and CVR the cerebrovascular resistance. Increases in intracranial pressure are transmitted to the venous system.

In normotensive persons, changes in CVR keep CBF relatively constant over a wide range of pressures, from 60 to 150 mm Hg. In hypertensives, the lower limit of autoregulation occurs at a higher level. In both normotensive persons and those with uncomplicated essential hypertension, the lower limit of autoregulation is about 25% below the resting mean arterial pressure. In ischemic tissue, however, autoregulation is disrupted. Lowering the blood pressure too much can jeopardize viable tissue surrounding the infarct in a stroke patient (Blumenfeld and Laragh, 2001).

Always remember that you are treating a patient, not a blood pressure chart.

Pulsus Paradoxus

When the sphygmomanometer was disseminated, observers began quantitating the degree of drop in systolic blood pressure that normally occurs during inspiration. Many pathologic conditions were found to cause an exaggeration of this normal phenomenon, even though the pulse was still palpable (i.e., contemporary pulsus paradoxus).

Historic Note

You are probably wondering why this phenomenon is called "pulsus" when it generally refers to a drop in blood pressure during inspiration. In fact, it was discovered by Richard Lower (1631–1691), a Cornish physiologist, before the sphygmomanometer was even invented. He noticed the weakening of a patient's pulse with inspiration. He reasoned that the phenomenon was caused by adhesions because the necropsy showed a thickened pericardium, which was adherent to the diaphragm. Lower's observation remained unappreciated, and the phenomenon awaited rediscovery by Kussmaul, who gave it its name (Kussmaul, 1873). (The title of his work, "Concerning Callous Mediastinopericarditis and the Paradoxical Pulse," possibly contributed to the erroneous belief that constrictive pericarditis produces pulsus paradoxus. The patient who was described in the paper actually had an exudative component to his pericardial disease discovered at autopsy, and today, this would have been stressed in the titling of the report.) In the patient that Kussmaul examined, the pressure change was so dramatic that the palpable pulse itself disappeared during inspiration. The paradox was that the pulse went away, whereas the central heartbeat continued.

Pathophysiology

The normal systolic pressure drop during inspiration is explained by a number of factors (Guntheroth et al., 1967). First, the high negative intrapleural pressure sucks blood into the venae cavae and increases filling of the right atrium and, hence, of the right ventricle. Some workers have suggested that with increased right ventricular volume, the interventricular septum may bulge into the left ventricular outflow tract, decreasing the stroke volume. Other workers have pointed out that during inspiration the highly negative intrapleural pressure increases the pulmonary blood volume and therefore momentarily decreases left atrial and left ventricular filling, decreasing the stroke volume in that way. Most authorities feel that an abnormal pulsus paradoxus is usually produced by accentuations in these basic mechanisms. Distortion of the abnormal pericardial sac by descent of the diaphragm (Dock, 1961) and various other subsidiary mechanisms (Spodick, 1964) may sometimes be operant in pericardial disease.

Criteria

As pulsus paradoxus is, to some degree, a normal phenomenon, at what point does it have clinical significance? Currently, almost all authorities define an inspiratory fall in the systolic pressure of greater than 10 mm Hg as abnormal. A dissenting minority have presented data suggesting that the definition of abnormality should actually be a fall greater than 10% of the (expiratory) systolic blood pressure (Reddy et al., 1978).

A Method

To determine the pulsus paradoxus, repeat the blood pressure measurement, lowering the mercury ever so slowly while approaching the previous systolic blood pressure. At first, you will hear the Korotkoff sounds only during expiration; this is the first number to record. Continue to lower the cuff pressure (1 mm per heartbeat) to the highest value at which the Korotkoff sound is heard with each beat, including those that occur during inspiration. This is the second figure. The difference between the two is the value of the pulsus paradoxus in mm Hg.

A Self-study

While you measure his systolic blood pressure, have your partner breathe in and out against resistance, for example, through the center cardboard from a toilet paper roll, with the distal end squeezed together. If he generates significant inspiratory and expiratory intrapleural pressures, an abnormal pulsus paradoxus will be produced (Sapira and Kirkpatrick, 1983). One might prefer, for aesthetic reasons, to use one's fist to generate the resistance. When done properly, this exercise also slows up the phases of respiration, giving the novice more time to make the measurements.

In many normal people, it is even possible to appreciate a drop in the systolic blood pressure by palpation at the radial artery as the subject takes a very deep breath. Try it on yourself: While palpating your radial pulse, suddenly take a deep breath. Pay attention to the pulse during the next two beats. What happens to the wave amplitude?

Many people can detect a difference. If you are not sure you can feel the change, repeat the experiment by breathing in and out against a strong airway resistance, as described above.

For the Attending. This is probably one of the most important parts of the teaching of pulsus paradoxus both because it uses a physiologic approach and because the discussion of pulsus paradoxus can be wrong even in a standard textbook (Chamberlain and Ogilvie, 1974).

Causes of Abnormal Pulsus Paradoxus

Between 70% and 100% of patients with pericardial tamponade exhibit this finding (Kuhn, 1976; Reddy et al., 1978). The lower figure probably includes cases of chronic pericardial tamponade in which the pericardium has had an opportunity to distend and acute cases in which the pericardium has not been stretched; probably all have the finding.

Abnormal pulsus paradoxus has been described in 80% of cases of asthma (Vaisrub, 1974); it appears when the forced expiratory volume in 1 second (FEV_1) is reduced to about 0.5 to 0.7 L (Rebuck and Pengelly, 1973). It also occurs in 50% of cases of shock, especially those with an increased peripheral resistance and a decreased blood volume (Cohn et al., 1967); in 30% to 45% of cases of effusive, "constrictive" pericarditis (Braunwald, 1980; Wise and Conti, 1976) but not in true dry constrictive pericarditis (Spodick, 1984); in about 30% of cases of pulmonary embolism (Cohen et al., 1973); and occasionally, in right ventricular failure (McGregor, 1979), severe congestive failure (Sale et al., 1973), right ventricular infarction (Greenberg and Gitler, 1983), obesity (Kuhn, 1976), and possibly patent ductus arteriosus (Gauchat and Katz, 1924). Some of the above etiologies are actually classes of etiology that may subsume specific mention of myocarditis, tumors of the mediastinum (Delp, 1975), pulmonary emphysema, paramediastinal effusion, endocardial fibrosis, fibroelastosis, myocardial amyloidosis, scleroderma, mitral stenosis with right-sided cardiac failure, and tricuspid stenosis (DeGowin, 1965).

False Negatives

There are certain situations in which one would expect pulsus paradoxus, but an intervening problem interferes with the requisite mechanism: either both ventricles do not fill against a common pericardial stiffness or the respiratory changes alternately favoring the right and left heart do not occur. Examples of these intervening confounders that produce false negatives are far advanced left ventricular hypertrophy, severe left heart failure, atrial septal defect, severe aortic insufficiency, severe tamponade with extreme hypotension, "right heart tamponade" (from a low-compliance left ventricle), loculated pericardial fluid (which prevents equalization of ventricular diastolic pressures), and low-pressure tamponade (Spodick, 1983).

Reversed Pulsus Paradoxus

An inspiratory *rise* of the systolic blood pressure is seen in idiopathic hypertrophic subaortic stenosis, in isorhythmic ventricular rhythms, and with intermittent inspiratory positive-pressure breathing in the presence of left ventricular failure (Massumi et al., 1973).

Unusual Pulse Pressures

An extremely *widened pulse pressure* [i.e., ($BP_{sys} - BP_{dias}$) > 50% BP_{sys}] may be seen in conditions associated with a high stroke volume (see Chapter 17). Aortic insufficiency is the best known example; others are hyperthyroidism, beriberi, pregnancy, fever, anemia, patent ductus arteriosus, severe Paget disease with extensive arteriovenous shunting through the diseased bone, and severe exfoliative dermatitis with shunting through the diseased skin. If an extremely wide pulse pressure is found in only one limb, one should search for an arteriovenous fistula in that limb. The Branham sign (see later in this chapter) will be confirmatory even without angiography.

Note, however, that in Western societies, pulse pressure increases with age, owing to fibrosis of the arterial wall and atherosclerotic deposits. With hypertension, the difference between systolic and diastolic pressure is often greater than this, without being considered abnormally wide.

It should be noted that patients with high stroke volume will not always have a widened pulse pressure. Patients with cirrhosis, for instance, so rarely have sufficient arteriovenous shunting to cause a widened pulse pressure that cirrhosis never appears in the differential diagnosis of the finding.

Many of the signs associated with aortic insufficiency are really signs of high stroke volume and so may also be associated with other diseases in the latter's differential diagnosis.

A *narrowed* pulse pressure may be defined as one that is less than 25% of the systolic pressure. It suggests decreased stroke volume and may be seen in pericardial tamponade, constrictive pericarditis, tachycardia, or aortic stenosis (see Chapter 17). (Artifactually narrowed pulse pressure may sometimes be produced in conditions of severely heightened vasomotor tone with increased peripheral vascular resistance, for example, cardiogenic shock. Like other blood pressure artifacts, it can be unmasked with a direct measurement of the intra-arterial pressure.)

A Chrestomathy of Artifacts

Auscultatory Gap

The auscultatory gap is fortunately a rare phenomenon in indirect blood pressure determination. At some pressure below the systolic pressure, the Korotkoff sounds fade out, to fade in again at a lower pressure, persisting then down to the true diastolic pressure, where they disappear for the last time. Figure 6-2 shows a blood

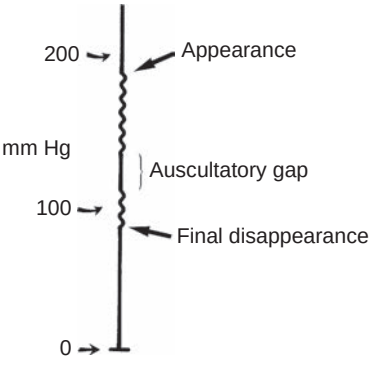

Figure 6-2 The auscultatory gap.

pressure determination that has an auscultatory gap. The points of first disappearance and of second reappearance mark the borders of the auscultatory gap.

The danger of the auscultatory gap lies in not realizing that it is there. In that instance, one might conclude that the diastolic pressure is much higher than is really the case. Alternately, if one did not detect the true systolic pressure by palpation first, one might begin searching for the systolic pressure inside the auscultatory gap, taking the point of reappearance of the Korotkoff sounds to be the systolic pressure and missing an extremely elevated systolic pressure. Either way, a serious therapeutic error might be made.

The auscultatory gap is most likely to appear in the obese arm, especially if the physician pumps up the blood pressure cuff slowly and traps a great deal of blood in the arm's venous compartment (Ragan and Bordley, 1941). Another way to trap blood is to pump the blood pressure cuff up a second time immediately following the first determination, without allowing a minute or two for the trapped blood to escape. The mechanism suggests the remedy. Having the patient with an obese arm hold the arm straight up in the air when you pump up the cuff the first time, and quickly inflating the cuff above the palpable systolic pressure, would help prevent the initial venous pooling.

Effects of Vessel Wall Stiffness

The stiffness or laxity of the vessel wall affects the propagation of the pressure waves and may cause either an artifactual increase or decrease in the indirectly determined pressure, depending on the circumstances. In the Hill sign (discussed in Chapter 17), the apparent systolic pressure is higher than the actual pressure because of the extra pressure waves that may be propagated or reverberated along a very lax vessel wall. As you might expect, a stiff wall could have the opposite effect (Cohn, 1967; *vide infra*). Furthermore, just as a lax wall can produce an artificially low diastolic blood pressure in conditions of high stroke volume such as aortic insufficiency, a stiff wall might produce an artifactually high value (Messerli et al., 1985).

Pseudohypotension

When simultaneous direct and indirect blood pressure measurements were made on patients in shock (Cohn, 1967), it was found that subjects with a high peripheral vascular resistance had damping of their arterial wall soundboards, and the Korotkoff sounds were produced so poorly that both the systolic and diastolic pressures were significantly underestimated by the indirect technique (i.e., pseudohypotension). The low cuff pressures were not simply explained by a low cardiac output because, in the patients with shock and a *low* peripheral vascular resistance, the direct and indirect methods gave equivalent results. Furthermore, Cohn could reproduce the pseudohypotension by infusing vasopressors into the arm circulation of normal volunteers.

Pseudohypertension

This stiff wall artifact, unlike the above, is not related to sound generation but results from the fact that the arterial wall is difficult to compress. The cuff pressure will be the sum of the pressure required to collapse the artery plus the pressure of the column of blood. Both the systolic and diastolic pressure measurements will be artifactually high (Messerli et al., 1985). The phenomenon is analogous to cuff hypertension.

You can judge the stiffness of the arteries by feeling the pulse and then occluding the artery proximal to the pulse with a blood pressure cuff or your finger, a maneuver described by Osler (Mishriki, 1987). If the distal artery can still be felt unchanged, even after the pulse is obliterated, the patient has sufficient arteriosclerosis to produce some degree of pseudohypertension.

The remedy for both pseudohypotension and pseudohypertension is the touchstone of science: an independent covariable—in this case, the direct intra-arterial blood pressure determination.

Other Vagaries of Blood Pressure Measurement

Nurses often obtain lower blood pressures than physicians (Moutsos et al., 1967). Some psychosomatic studies reveal that pleasant conversation will lower the blood pressure but that the pressure will rise if an unpleasant or tension-filled subject is introduced, as in the so-called *stress interview*. These phenomena are further examples of the point made earlier: there is no such thing as "the" blood pressure.

Finally, there is the unconscious bias of the physician, manifest in the fact that physicians tend to record the terminal digits "8" and "0" more often than could be accounted for by chance (Pemberton, 1963). Odd terminal digits are almost never recorded (T. Fagan, *personal communication*, 2009).

Other Tests that Use a Blood Pressure Cuff

Any of the tests involving the assessment of an arterial pulse may be made quantitative by employing the blood pressure cuff. Most of these will be found in the chapter concerned with the arterial circulation, although a few (e.g., pulsus alternans) will be found in the next section.

The Trousseau test is done with a blood pressure cuff but does not involve measuring the blood pressure. Accordingly, it is described under the neurologic exam in Chapter 26. Sternbach's pain thermometer (see Chapter 3) also employs a blood pressure cuff, as does a test for thrombophlebitis (see Chapter 19).

The Pulse

Doctor Pinch: Give me your hand and let me feel your pulse.
—William Shakespeare, *Comedy of Errors*, Act 4, Scene 4

This section discusses the frequency and regularity of the heartbeat as detected peripherally. It does not consider the arterial pulse wave contour, which is best detected at the carotid artery and is recorded under the "arterial" part of the peripheral vascular examination (see Chapter 18). Similarly, the palpable consistency of the arterial wall itself (which contributes to the estimation of the biologic, as opposed to the chronologic age) is also recorded under the "arterial" part of the peripheral vascular examination (see Chapter 18).

Frequency

The pulse is universally expressed in beats per minute.

A Method

At the radial artery (or the carotid, if both radials are impalpable), count the number of impulses in a 1-minute period. Later, one can shorten this time to 30 seconds and double the counted beats if they are between 30 and 50. However, whenever one decreases the sampling time, one decreases the opportunity of finding the abnormalities.

Normals

In the adult, a rate faster than 100 per minute is considered a tachycardia. A rate below 50 per minute is a bradycardia by the usual definition. However, as the physical examination is a screening method, we want to accept many false positives but not have any false negatives. Therefore, we will consider a pulse rate below 60 per minute to be abnormal, that is, worthy of further consideration, with the understanding that it may turn out to be a normal variant.

An Epistemologic Note. If, after further searching, nothing else can be connected with a finding, it is considered of peripheral rather than critical significance. When assembling all the findings at the end of the examination, one would use the critical findings to compose the differential diagnosis. One does not know in advance whether a finding will be critical or peripheral, so initially all must be taken seriously (and not assumed to be peripheral). Examples would be a bradycardia in a healthy young sprinter applying for insurance (peripheral) versus bradycardia in an untreated cretin (critical). (See etymologic note on "cretin" in Chapter 14.)

Regularity

The pulse may be described as regular when every beat comes at the expected time. An irregular pulse may be regularly irregular (when the irregularities can be predicted) or *irregularly* irregular (when they cannot).

Although the study of arrhythmias in the modern era correctly requires an electrocardiograph machine, much can still be learned from an examination of the pulse, including which patients need an electrocardiographic recording. Additional information about arrhythmias can be obtained from auscultation of the first heart sound (see Chapter 17), carotid sinus massage (see Chapter 18), and observation of the jugular venous pulses (see Chapter 19).

Regular Tachycardias

The rate and regularity are clues to the most probable type of arrhythmia. If there is a regular tachycardia, it is most likely sinus tachycardia if the rate is between 100 and 125; atrial flutter with 2:1 block if the rate is from 125 to 165; and paroxysmal atrial tachycardia (PAT) if the rate is from 175 to 200.

Above 200 per minute, the prognosis becomes ominous either because of the etiology or because of the physiologic effects of the rapid rate itself. Ventricular tachycardia may have a rate of about 250 at which point there is often no measurable blood pressure.

A Note on Sinus Tachycardia

Sinus tachycardia may be seen in a wide variety of abnormal conditions: any type of congestive heart failure or any high-output state, such as fever, anemia, or thyrotoxicosis. As a sign, sinus tachycardia is sensitive for pathology, so it is important not to disregard it. (For example, a pulse rate of 90 or greater has a sensitivity of 84% for hyperthyroidism in patients aged 10 to 29, 79% in patients aged 30 to 39, and 75% in patients aged 60 to 83 [Nordyke et al., 1988].) However, there are many false positives.

The sinus tachycardia of excitement disappears during sleep. Most other sinus tachycardias lessen during sleep but that from thyrotoxicosis sometimes continue unabated.

The following is an example of the potential importance of this finding. Sinus tachycardia was once noted in a research subject. Her "innocent" systolic murmur was rediscovered, as well as her wide fixed split second heart sound. This led to the erroneous but testable hypothesis that she had an atrial septal defect. Instead, at cardiac catheterization, she was found to have a partial anomalous pulmonary venous return, a condition that was of great significance in the study because it might have affected the metabolism of the experimental drugs. In this case, the tachycardia was a central finding.

One feature that may help distinguish sinus tachycardia from PAT is that the former begins with gradual acceleration and ends with gradual deceleration (Fig. 6-3A), whereas PAT classically has an abrupt onset and termination (Fig. 6-3B). (However, the excitement caused by the arrhythmia might increase circulating catecholamines. The PAT could then convert to a sinus tachycardia, which would slowly decelerate as the catecholamines waned.)

There are two types of sinus tachycardia that have eponyms. In patients with chronic lung disease or other causes of right-sided hypertension, stretching of the right atrial receptors initiates a reflex resulting in chronic sinus tachycardia. This is known as the *Bainbridge reflex*.

The *Branham sign* is a sinus tachycardia due to an arteriovenous fistula in which the heart rate can be slowed to normal upon occlusion of arterial flow (by means of a blood pressure cuff) to the limb containing the fistula. When the blood pressure cuff is deflated and blood flow to that limb resumes, the heart rate immediately rises.

Regularly Irregular Pulses

Second-degree Heart Block

If some of the atrial impulses are blocked and do not reach the ventricles (the definition of second-degree heart block), a regularly irregular pulse may result. One way of naming the second-degree heart blocks is by ratio (e.g., 5:4, 4:3, 3:2, and 2:1). The first number in the ratio is the number of atrial impulses in a recurring sequence and the second number is the number of times (in each series) that the atrial impulse activates the ventricle. As there is almost never time for a ventricular escape beat (unlike third-degree heart block in which the ventricles are never excited by the atrial impulses), there is simply a skipped beat. The ratio of the block is usually very regular.

What one feels is a series of regular pulses, then a missing beat, then again the same number of regular pulses, and—right on cue—the missing one. With 5:4 block, there are four pulses and then a skipped one; with 4:3 block, there are three beats and then a miss (Fig. 6-3C). Whenever one feels such a series, with the missed beat coming right on time, each time, one should think of second-degree heart block and examine the neck veins immediately (see Chapter 19) and do an electrocardiogram (ECG) as soon as possible. With 2:1 block, there is no way of knowing that a beat is missing, unless one looks at the neck veins; thus, this particular rhythm is actually a regular one.

FIGURE 6-3 The meter of various arrhythmias. The notation % means to repeat the previous measure. **A:** Sinus tachycardia. **B:** PAT. **C:** Mobitz type I second-degree heart block (4:3 Wenckebach); as the PR intervals lengthen before the dropped beat, the RR intervals decrease. **D:** Mobitz type II second-degree heart block (4:3). **E:** Mobitz type II second-degree heart block (5:4). **F:** Premature ventricular contraction with compensatory pause. **G:** Premature atrial contractions. (In real life, the time value of the first eighth note is not always exactly half a quarter note.)

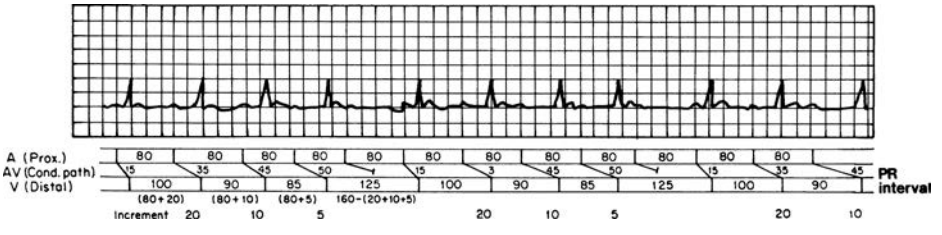

FIGURE 6-4 Mobitz I second-degree heart block (Wenckebach). This shows why Fig. 6-3C is marked accelerando and Fig. 6-3D is not. In Mobitz type I (but not type II), the amount of PR prolongation decreases on successive beats ("increments"). This makes successive RR intervals shorter.

In addition to naming the second-degree heart blocks by their ratios of atrial to ventricular activities, they may also be named in terms of what the electrocardiographic PR interval is doing. If it is being gradually prolonged until the atrial impulse fails to be transmitted to the ventricles, it is called a *Wenckebach phenomenon*, after the doctor who first described it (Wenckebach, 1906), or a *Mobitz type I block* (Fig. 6-4). If, on the other hand, there is no lengthening of successive PR intervals prior to the skipped beat, it is called a *Mobitz type II block* (Fig. 6-3D and E). In Mobitz type I, there is a slight acceleration not seen in Mobitz type II (see the legend to Fig. 6-4 for the explanation).

Sinus Arrhythmia

The subtlest, and least important, of the regular irregularities is sinus arrhythmia. It is simply the clinically noticeable exaggeration of a normal phenomenon: the speeding of the heart rate with inspiration and the deceleration of the heart rate during expiration.

A Self-experiment. Take a deep breath while feeling your pulse. What happened? Now exhale and note what happens to the rate. If you do a Valsalva maneuver during expiration, the pulse will slow down even more.

Sinus arrhythmia is most frequently observed in healthy young persons, especially well-conditioned athletes.

Ectopic Beats

Bigeminy, which comes from the Latin word for twin, means that every other beat is an ectopic beat—either atrial or ventricular—so that the beats seem to come in pairs. Usually, bigeminy is caused by ventricular premature contractions and may be a sign of digitalis intoxication (though it is neither very sensitive nor specific for that

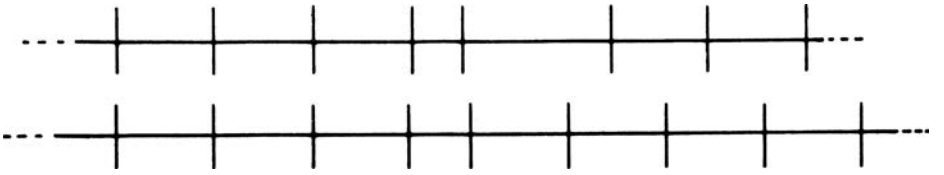

Figure 6-5 A graphical depiction of ectopic beats, each vertical stroke representing one pulse beat. Can you identify the ectopic beat in each tracing? Is the ectopic beat atrial or ventricular? (See text.)

diagnosis). *Trigeminy* means that every third beat is ectopic so that the pulse seems to be divided into triads. *Quadrigeminy* means that every fourth beat is ectopic.

Pulsus Alternans

Pulsus alternans is a regular irregularity in amplitude, a weak beat alternating with a strong beat. If it occurs during a tachycardia, pulsus alternans may be quite benign, depending on the underlying disease. When it occurs with sinus rhythm, however, as in left ventricular failure due either to ischemic heart disease or to hypertensive cardiovascular disease, it is of ominous significance because the heart apparently is unable to pump out an adequate stroke volume on alternate beats. The combination of an S3 gallop (see Chapter 17) and pulsus alternans has been called the "death rattles of the heart" (A. Goel, *personal communication*, 2004).

The meter of pulsus alternans may also be regularly irregular because the weak beat can be slightly early or late, playing off the rhythm in the manner of Errol Garner.[2] Usually, however, the pulse feels regular because the premature occurrence of the weak beat (Friedman, 1956) is compensated for by its prolonged transit time to the periphery (Friedberg, 1956).

A better method for detecting pulsus alternans than simple palpation of the pulse is to pump the blood pressure cuff up above the systolic pressure. Deflating it slowly, search for a point at which only alternate beats are felt (and heard). This will be above the point at which all beats are felt (and heard). (This method is analogous to that used for determining pulsus paradoxus, except that the alternation is not related to the respiratory cycle.)

Pulsus alternans may or may not be associated with electrical alternans, the electrocardiographic alternation in the height of the QRS in any given lead. In cases of tachycardia, such an association is neither surprising nor ominous. However, in cases of congestive heart failure, the occurrence of electrical alternans with pulsus alternans has a serious prognosis.

Irregularly Irregular Pulses

There are basically four irregularly irregular pulses that are of concern at the bedside: premature atrial contractions (PACs), premature ventricular contractions (PVCs), atrial fibrillation, and multifocal atrial tachycardia. The two types of premature contractions are easy to identify when they are episodic (*vide infra*). However, when combined or frequent, the pulse can be so confusing that a confident determination cannot be made without the ECG. Atrial fibrillation is highly chaotic in its usual form. It has been called *delirium cordis* because the only thing predictable about the beat is its unpredictability. These irregular irregularities are best learned at the bedside. If you prepare yourself by reading, you will be able to take advantage of learning opportunities that present themselves, and you can return to these pages later for a leisurely review.

For the Attending. There is also a fifth type of irregularly irregular pulse, sinus arrest, and a sixth, sinus exit block. In these situations, a sinus impulse never reaches the atria. If the pause between beats is exactly two RR intervals, there is no way to distinguish the two, even with an ECG strip (because this does not show sinus node events, only atrial and ventricular activity). If the interval is less than exactly two RR intervals, the pulse taker could make a diagnosis of sinus arrest. However, the arrest might be for longer than two RR intervals, albeit not an exact multiple. To make things more confusing, the longer a sinus pause, the greater the likelihood of an escape beat from a lower pacemaker. Thus, some very confusing pulses can be generated. Because of the episodic nature of these pulses, their rarity, and the ubiquity of Holter monitoring, I have abandoned the teaching of these pulses.

There is also no way to distinguish 2:1 sinus exit block from 2:1 atrioventricular block, a distinction that can be significant both in terms of underlying diagnosis, and in the case of the latter, in the use of drugs that could further slow the atrioventricular conduction. If carotid sinus pressure (see Chapter 18) should geometrically increase the block (slow the pulse), the diagnosis of atrioventricular block would seem secure. Conversely, if there were no effect, it would be suggestive of exit block, although the test would not be definitive.

Premature Ventricular Contractions

This type of ectopic beat is followed by a *fully compensatory pause*. The pause permits the beat *after* the ectopic one to occur just on time, that is, at two normal RR intervals after the last *normal* beat. In other words, the shortened RR interval before the ectopic beat plus the lengthened RR interval after the ectopic beat are exactly equal to twice the normal interval. Demonstrate this fact to yourself using Fig. 6-5.

One effect of the compensatory pause is to allow a longer filling period and hence greater stroke volume. Thus, the postextrasystolic pulse amplitude should normally be greater. In fact, it is usually this postextrasystolic contraction that attracts the patient's attention, rather than the extrasystole itself. Patients often describe it by saying "my heart flipped over."

There are two situations in which the postextrasystolic pulse amplitude is less than expected. The first is a state of impaired contractility, as in congestive heart failure. The second is idiopathic hypertrophic subaortic stenosis. If the Frank–Starling curve is still normal, the greater filling increases the strength of contraction of all the cardiac muscles, including the obstructing ring. The net effect is to blunt the expected rise in stroke volume.

[2] Errol Garner (1921–1977) was a completely self-taught jazz pianist who never learned to read music. His distinctive style called for a level of virtuosity seldom approached since.

Unfortunately, in both cases, we are attempting to compare the actual beat with "what should have been." The absence of an increase over normal may be difficult to detect because the natural comparison is with the preceding (extrasystolic) beat, which is of diminished amplitude. However, in the rare cases in which the postextrasystolic beat is definitely less than the following beat, the differential diagnosis is reduced to the two possibilities above. Although perhaps not worth searching for, to those capable of appreciating it, this phenomenon may be the free gift of circumstance.

For the Very Advanced Student. Sometimes, one may wish to induce a PVC, especially when one wants to auscultate for the effect of the postextrasystolic beat on a murmur (see Chapter 17) or to let the patient identify such a beat as the cause of his palpitations. Some physicians have actually struck the patient sharply on the precordium. (This is *not recommended*, as it conceivably could induce ventricular tachycardia or fibrillation.) I have not had success with this technique but have had some luck with the noxious stressor of mental arithmetic, when vigorously applied to susceptible patients (Lown et al., 1978).

Note that the fully compensatory pause is longer than the pause after the skipped beat in Mobitz type I block. In the latter instance, the exact length of the interval containing the skipped beat is twice the PP interval minus the sum of the increments in PR intervals before the dropped beat (Cabeen et al., 1978) or twice the PP minus the difference between the first PR interval after the missed beat and the last PR interval before it (Fig. 6-4).

Premature Atrial Contractions

With PACs, there is no compensatory pause. The RR interval after the ectopic beat is equal to the normal RR interval. As shown in Fig. 6-6, the PAC's ventricular contraction is preceded by a normal activation sequence, including a His bundle spike, and followed by a "resetting" of the sinus node.

For musicians, the difference between PVCs and PACs is illustrated in Fig. 6-3F. The PVC is simply a syncopated beat; the fourth note in measure two comes in exactly "on the down beat." You can make this diagnosis by tapping your foot in time at the bedside. On the other hand, the PAC initiates a new time signature, although the conductor's tempo does not change. If you attempt to tap this out at the bedside, you will find yourself out of synch following the premature contraction; the heart will now be beating on the "up beat" (Fig. 6-3G).

In point of fact, electrocardiographic PACs with fully compensatory pauses do occur, rarely and inexplicably.

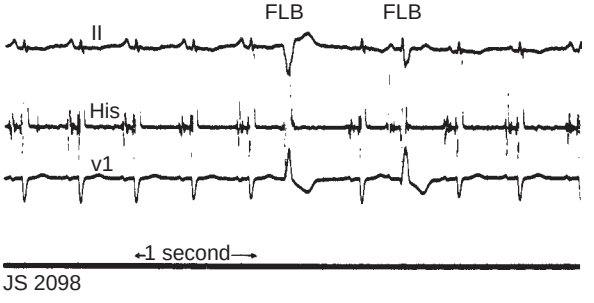

Figure 6-6 Simultaneous electrocardiographic (leads II and VI) and His bundle tracings. The first funny-looking beat (FLB) is a premature ventricular contraction; the second FLB is premature atrial contraction. Considering the second FLB, note that (i) the QRS is preceded by a P wave, (ii) the His bundle recording (middle) shows the same activation sequence as the normal beats, and (iii) there is no compensatory pause. With the first FLB, none of the above are true. (Tracing courtesy of Drs M. Fisher and R. Peters, MD, with permission.)

Atrial Fibrillation

One bedside trick that helps to identify atrial fibrillation is the *apical–radial pulse deficit*. If one simultaneously measures the apical ventricular rate and the radial pulse, one will find the radial rate to be lesser in all cases of atrial fibrillation except those at very slow rates (under 50 per minute). This is because some of the ventricular contractions are preceded by short diastoles with such poor ventricular filling that there is insufficient stroke volume to transmit the pressure wave out to the radial pulse. Occasionally, patients with frequent multifocal PACs and PVCs can also generate small apical–radial pulse deficits.

If a digitalized patient with a prior diagnosis of chronic atrial fibrillation presents with a perfectly regular pulse, one should suspect digitalis intoxication with a regular nodal rhythm and atrioventricular dissociation. (Note that in this form of "regularized" atrial fibrillation, the apical–radial pulse deficit also disappears.)

When the ventricular rate is speeded by drugs or exercise, atrial fibrillation usually becomes more irregular and ectopy tends to become more regular. However, this test has fallen into disrepute because there are many false negatives unless one gets the heart rate up to 140 per minute. Also, ectopy due to an "anoxic focus" may worsen with exercise, producing a false positive.

The following aphorisms apply to atrial fibrillation:

1. Atrial fibrillation plus stroke suggests cerebral embolism.
2. Atrial fibrillation plus acute abdominal pain suggests a superior mesenteric artery embolism.
3. Atrial fibrillation by itself suggests ischemic heart disease, long-standing mitral valve disease (especially mitral stenosis), long-standing hypertensive heart disease, or recent onset of masked hyperthyroidism. If these etiologies are excluded, one might consider hypoxia, Wolff–Parkinson–White syndrome, or chronic myocardiopathy. Atrial fibrillation sometimes does occur without other demonstrable cardiac pathology.

Multifocal Atrial Tachycardia

An important difference between this rhythm and atrial fibrillation is that this rhythm is "regular enough" to permit valid blood pressure measurements because the filling is equal for most beats. Similarly, there may be no apical–radial pulse deficit with multifocal atrial tachycardia.

A Note on the History of Arrhythmias

When the patient has had an arrhythmia, you can often diagnose the type by beating out rhythms on the top of your desk and asking the patient to identify the one he experienced. Often, it is possible at least to exclude some arrhythmias. However, patients who had a very strong chronotropic stimulus, say from endogenous catecholamines, tend, in retrospect, to overestimate their heart rate.

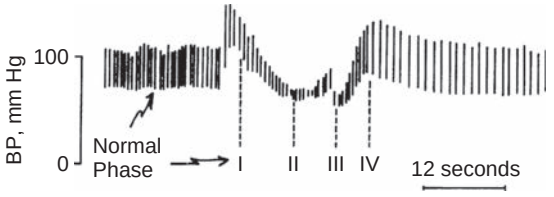

FIGURE 6-7 The Valsalva response.

Valsalva Maneuver

The Valsalva maneuver was invented in the 18th century by Valsalva for the laudable purpose of clearing the eustachian tubes (Nishimura and Tajik, 1986). It is still used for that purpose by divers. However, in medicine, it consists of expiration against a closed glottis (not against the occluded nares), sustained for about 10 to 25 seconds, depending upon the specific protocol.

In research protocols, the subject blows into a mouthpiece connected to a mercury manometer and generates the desired pressure (about 40 mm Hg). At the bedside, the patient is instructed to take a deep breath and strain as if to have a bowel movement or to lift something very heavy. Alternately, he can be asked to push against the examiner's hand, which is placed on the abdomen. Dr Ashish Goel finds the easiest way to get a patient to do a Valsalva maneuver is to ask him to put his thumb in his mouth and blow on it as if blowing up a balloon.

In the 20th century, physiologists discovered that this maneuver produced a variety of cardiovascular effects. The response has four phases (Fig. 6-7 and Table 6.1).

Abnormalities in the autonomic nervous system cause aberrations in this response. However, as you will notice, some of the blood pressure changes last but a few beats, so they cannot be detected at the bedside with an indirect blood pressure measurement. Accordingly, the Valsalva maneuver never gained in clinical popularity until phonocardiologists discovered that the change in murmurs during certain phases of the Valsalva response could help identify their etiology (see Chapter 17).

I have abandoned the teaching of the pulse and blood pressure responses, even though many books allude to them, because they cannot be measured using the contents of a black bag. However, some of the pulse changes can be picked up at the bedside by an astute clinician or even a sophomore equipped with a portable electrocardiograph machine.

For the Attending. The three methods described below should each detect the same autonomic dysfunction, produced by the same diseases.

1. *Method of Dr Gerhard Muehlheims of Missouri*. Look for the post-Valsalva overshoot reflex bradycardia (phase IV). It is lost in altered sympathetic states, such as congestive heart failure and the faithful ingestion of noradrenolytic agents, such as clonidine, methyldopa, or reserpine.
2. *Method of Ewing*. The post-Valsalva bradycardia is also lost in the autonomic neuropathy of diabetes and in end-stage renal disease (Blake et al., 1989). One way of quantitating this requires an electrocardiograph machine. The subject performs the Valsalva maneuver for only 15 seconds, and the shortest RR interval during this time (phase II) is taken as the "tachycardia," or the denominator of the ratio to be calculated. The longest RR interval in the post-Valsalva overshoot period (phase IV "bradycardia") is the numerator. A ratio of 1.21 or more is the arbitrarily stated normal, 1.11 to 1.20 is borderline, and 1.10 or less is abnormal. The ratios are determined for three trials and averaged (Ewing et al., 1973).
3. *Method of Thomas*. The Mayo Clinic uses this method (Thomas et al., 1981) in the evaluation of orthostatic hypotension, which often has an autonomic etiology. Patients with orthostatic hypotension due to volume depletion should have a normal Valsalva response by this method. The RR interval is converted into a pulse rate. The maximum instantaneous heart rate observed during phase II is divided by the minimum heart rate obtained during phase IV, the post-Valsalva overshoot period. A ratio of 1.25 or above is taken to be normal, whereas ratios of less than unity are abnormal.

TABLE **6.1** *Phases of the Valsalva response*

Phase	Action	BP	Pulse	Mechanism
I	Onset of strain	Increase	Stable	Compression of aorta
II	Continued strain	Decrease	Increase	Decreased venous return; increase in sympathetic tone
III	Release	Decrease	Stable	Blood pools in pulmonary vasculature
IV	Recovery	Increase	Decrease	Increased cardiac output due to increased venous return with continued vasoconstriction due to sympathetic activity; reflex bradycardia

From Schatz IJ. Orthostatic hypotension: II. Clinical diagnosis, testing, and treatment. *Arch Intern Med.* 1984;114: 1037–1041 and Thomas JE, Schirger A, Fealey RD, et al. Orthostatic hypotension. *Mayo Clin Proc.* 1981;56:117–125, with permission.

A Caveat. The tests are said to be invalid (Schatz, 1984) in congestive heart failure or obstructive lung disease. I suspect that this is because of the sympathetic abnormalities that may occur in the former and the Bainbridge reflex that may occur in the latter.

Respiration

His breathing was irregular; it would entirely cease for a quarter of a minute, and then it would become perceptible though very low, then by degrees it became heaving and quick, and then it would gradually cease again. This revolution in the state of his breathing occupied about a minute, during which there were about 30 acts of respiration (Cheyne, 1818).

A Method

After taking the pulse rate, continue holding the patient's wrist. While looking toward your watch, observe the patient's chest for another minute, without speaking, counting the respiratory rate. If one counts for a full minute, one will not miss an irregularity such as Cheyne–Stokes or Biot respirations (*vide infra*).

Respiratory Rate

The normal mean resting respiratory rate for recumbent healthy young men is 13 per minute in the morning and 15 per minute after lunch. No normal subjects had rates greater than 19 per minute.

Bradypnea may be defined as a respiratory rate of less than 10 per minute. It can be seen in severe hypothyroidism and in central nervous system disease, especially that due to pharmacologic agents (e.g., narcotic analgesics and hypnotics). Bradypnea does not always mean alveolar hypoventilation, which is now operationally defined as an elevated arterial partial pressure of carbon dioxide.

Apneustic breathing is a bradypneic form of preterminal respiration seen in comatose patients. The patient will hold the breath at the end of inspiration before the Hering–Breuer reflex initiates the next cycle with expiration. Apneustic breathing is most often a sign of pontine disease (e.g., hemorrhage or basilar artery occlusion, but it occasionally accompanies hypoglycemia, anoxia, or severe meningitis) (Plum and Posner, 1972).

Tachypnea may be defined as a respiratory rate of 20 per minute (or greater). It is abnormal except in chronic care patients over the age of 67 years in whom the normal range of respirations is 16 to 25 per minute (McFadden et al., 1982). Tachypnea is seen in a wide variety of cardiac, pulmonary, metabolic, central nervous system, and infectious diseases.

1. The above definition of tachypnea may permit too many false negatives. A stricter definition would be more sensitive for pulmonary embolus: only 8% of patients with pulmonary embolism breathe at a rate less than 16 per minute (Fulkerson et al., 1986).
2. Cope (Silen, 1979) pointed out that a respiratory rate twice the normal rate in a patient with a suspected acute abdomen was evidence of primary thoracic disease with secondary referral of symptoms to the abdomen.
3. Tachypnea may be of value in the differential diagnosis of hypovolemic shock versus the hypotension of sepsis. If the respiratory rate is elevated, some clinicians favor the diagnosis of sepsis.
4. Tachypneic patients who are in congestive heart failure have waterlogged lungs and pant like dogs because of respiratory midposition. Tachypneic patients who have obstructive lung disease "breathe off the top" from a position of chest expansion and, additionally, sometimes have "door stopping" when air trapping occurs during expiration. The best way to learn to make these observations is in the company of an older clinician.
5. The hyperventilation syndrome may be diagnosed by reproducing the symptoms (such as light-headedness and paresthesias), and then showing that they can be relieved by breathing into a paper bag. Have the patient follow your respiratory rate and exaggerated respiratory excursion. When you start to become light-headed, continue to move your shoulders and arms as if still taking deep breaths but breathe only on about one third of the excursions.

   This diagnostic maneuver is actually therapeutic in that the patient learns that you truly understand what is happening to him and that you are calm about it. That mastery spreads to him, especially when he learns that the paper bag works.

Effort

In addition to rate, one should observe the ease of respiration. Patients with severe emphysema attempt to prevent terminal respiratory airway closure by pursing their lips. Other types of pulmonary and cardiac tachypnea can be accompanied by a variety of audible sounds ranging from intentional vocalizations to grunting, stridor, wheezing, and audible breathing. Some patients may grunt because sputum, blood, or a tumor is occluding an airway, and others may grunt, whenever they take a deep breath, because of pleuritis. Some patients who grunt with respiration have an acute abdomen and no intrathoracic pathology. Grunting, like pursed-lip breathing, may help prevent terminal airway closure. Grunting is also a useful clue to the presence of pneumonia or pulmonary fluid in infants. Patients are said to have labored breathing when they are concentrating their efforts on breathing, even if they make no noise.

Patients may assume a particular position in order to breathe better. (Orthopnea, platypnea, and trepopnea are discussed in Chapter 5.)

Respiratory Pattern

Cheyne–Stokes Respiration

Cheyne–Stokes respiration (periodic breathing) is a regularly irregular pattern in respiratory volume, which ranges from apnea to hyperpnea and back again (Fig. 6-8A). The classic description (Cheyne, 1818) is quoted at the beginning of this section. Cheyne's original patient had both a diseased heart and enlarged cerebral ventricles, and the debate over whether Cheyne–Stokes respiration has primarily a cardiovascular or a neurologic etiology continues to the present time.

Brown and Plum (1961) studied 28 patients with Cheyne–Stokes respiration, plus control subjects from the following groups: normals, patients with congestive heart failure, and patients with unilateral and bilateral cerebral vascular disease. Every subject with Cheyne–Stokes respiration had an increased respiratory sensitivity to CO_2 resulting from bilateral supramedullary brain dysfunction. Peak ventilation coincided with maximal $PaCO_2$ and apnea with low

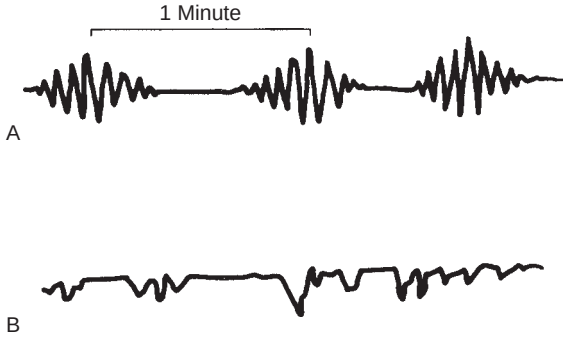

Figure 6-8 **A:** The classic spirogram of Cheyne–Stokes respiration, a regularly irregular pattern. The flat lines represent periods of apnea. Note that when the patient is breathing, the amplitude changes, but not the frequency. **B:** An example of Biot breathing in a patient with tuberculosis meningitis, traced from Fig. 4 in Biot's paper. The respiratory activity is irregularly irregular in that frequency, respiratory depth, and periodicity vary in an irregular manner.

$PaCO_2$. The authors concluded (Brown and Plum, 1961) that periodic breathing is apparently neurogenic posthyperventilation apnea and that extracerebral abnormalities are not the primary cause. However, they also referred to an experiment in which it was possible to induce Cheyne–Stokes respiration in animals by artificially increasing the length of their carotid arteries, without otherwise altering brain function. Such an experiment could support either etiology, neurogenic or cardiovascular.

Karp et al. (1961) confirmed and extended the blood gas determinations of the previous workers and also noted that the circulation time across the brain was relatively prolonged during periods of apnea. The alteration in cerebral circulation was felt to be the most important factor, but the converse possibility that the changes in circulation were secondary events could not be excluded. Neurologists supporting the primacy of the central nervous system etiology of Cheyne–Stokes respirations have also reported similar fluctuations in other neurologic events. A most interesting example is the series of three patients with periodic breathing who demonstrated pupillary dilation during hyperpnea and constriction during the apneic phase (Sullivan et al., 1968). When apparently contradictory evidence supports each of two opposing theories on pathophysiology, time usually proves both of them to be right in some way.

It was formerly believed that Cheyne–Stokes respirations could only occur with an intact brainstem, but the classic pattern has been seen in partial pontine hematomas (Kase et al., 1980). With this background, we can better understand the clinical differential diagnosis of Cheyne–Stokes respiration.

The causes of Cheyne–Stokes respiration are as follows: congestive heart failure, meningitis, pneumonia, hypoxia (DeGowin, 1965), brain tumor, chronic nephritis, some poisonings, high-altitude mountain sickness, bilateral or unilateral cerebral infarction, damage to the central pontine tegmentum, bilateral disease of the descending motor pathways, pseudobulbar palsy, mild congestive heart failure accompanying some motor pathway diseases, posthyperventilation in patients without neurologic or cardiovascular disease (Brown and Plum, 1961), and the obesity cardiorespiratory syndrome (Karp et al., 1961).

Seemingly normal persons may have Cheyne–Stokes respiration during sleep. Although today we would suspect that such persons might have the sleep apnea syndrome, the abruptness with which a full inspiratory effort appears in the sleep apnea syndrome is not seen in Cheyne–Stokes syndrome but rather in Biot breathing, another form of irregular breathing.

Biot Breathing

Biot breathing (Fig. 6-8B) is an irregularly irregular breathing, characterized by more abrupt starts and stops than Cheyne–Stokes respiration and by an absence of periodicity. Biot breathing is much less common and has been less well studied. I consider them to be equally ominous, directing attention to the central nervous system, the meninges, and their blood supply. In point of fact, I have seen tracings supposed to represent Cheyne–Stokes respiration that were sufficiently irregular to resemble those published by Biot (Figs. 4 and 5 in Karp et al., 1961). Conversely, some of the tracings from Biot patients closely resemble those of Cheyne–Stokes respiration, and Biot's paper was actually entitled "A Contribution to the Study of the Cheyne–Stokes Respiratory Phenomenon" (Biot, 1876). Cheyne–Stokes breathing rarely leads to sudden apnea and cardiorespiratory arrest, whereas Biot breathing commonly does (J. Bass, *personal communication*, 1986).

Kussmaul Respirations

Kussmaul respirations are regular, deep, and usually fast. Unlike the other eponymous forms of breathing, the pattern is basically an exaggeration of the normal. It results from central hyperventilation and is a response to any type of acute metabolic acidosis, including salicylate intoxication and diabetic ketoacidosis. In metabolic acidosis, the loss of bicarbonate and resulting fall in the pH can be compensated for by removing proportional amounts of carbon dioxide, as the Henderson–Hasselbalch equation shows. The only feasible way to achieve this is hyperventilation. Patients with cardiac or pulmonary disease may also hyperventilate, not to eliminate carbon dioxide, but to increase the oxygenation of their blood. They will also appear to have "air hunger" or Kussmaul respirations. In patients with Kussmaul respirations but a normal respiratory rate, the increase in tidal volume can be detected by noting that the patient has trouble with conversation. The respirations cannot be inhibited for speech, so the patient must pause in midphrase to breathe.

In a potentially dehydrated child, the examiner should specifically look for hyperpnea (deep, rapid breathing) without other signs of respiratory distress, which is suggestive of acidosis. An abnormal respiratory pattern is one of the three best signs for 5% dehydration, with a positive likelihood ratio of 2.0 (Steiner et al., 2004).

Parkinson Disease

Peculiar respiratory patterns may occur in patients with postencephalitic Parkinson disease (Sacks, 1973). Without warning, one such patient experienced a sudden inspiratory gasp, followed by forced breath holding for 10 to 15 seconds, then a violent expiration, and finally an apneic pause for 10 to 15 seconds.

Temperature

He is so shaken of a burning quotidian tertian that it is most lamentable to behold.

—William Shakespeare, *King Henry the Fifth*, II, i

History

Though the significance of fever was long recognized and Galileo had an instrument for measuring air temperature in 1600, the path-breaking work on medical thermometry was not done until around 1850 by syphilologist Felix von Bärensprung and famous clinician Ludwig Traube (see Chapter 17). Finally, the Hippocratic "crisis" and "critical days" were shown to correspond to temperature curves. Rapid defervescence occurred with "lysis" of the illness. Carl August Wunderlich then brought thermometry into clinical use. Over 15 years, all patients entering his clinic or attended by him in hospital had their temperature regularly measured and recorded. Wunderlich's work was ridiculed as difficult and costly "fruitless fiddling." Indeed, the early thermometers were inconvenient, measuring 25 cm long and so plump that the English said they had to be carried under the arm "as one might carry a rifle." Wunderlich doggedly persisted in his work, bringing thermometry to life from a 250-year period of neglected existence, and gave it its indispensasble function in clinical practice. As a result of objective physical measurements, fever was demoted from its centuries-long status as an illness to a mere symptom (Rath, 1952).

Temperature Measurement

The temperature has traditionally been measured rectally or orally. The latter should be performed by placing the thermometer bulb under the tongue with the lips kept closed. With a mercury thermometer that has been well shaken down, equilibration requires about 3 minutes, while maximum accuracy requires 10 minutes (Blumenthal, 1992). With newer instruments using a thermistor, less than 60 seconds may be required. (*A self-study*: Try sticking the probes from several of these under your tongue at the same time. With your mouth closed, do the instruments record the same temperature?)

The rectal temperature is usually about 1°F (0.55°C) higher than the oral temperature. In patients who are tachypneic (breathing more than 20 times per minute), the difference averages 1.67°F (0.93°C), increasing with the respiratory rate and becoming independent of whether the patient is mouth breathing or not (Tandberg and Sklar, 1983). Other causes for falsely low oral temperatures include recent ingestion of cold substances or failure to keep the lips closed. Falsely high oral temperatures may result from failure to shake down the thermometer, ingestion of hot substances, or smoking. Patients should refrain from eating, drinking, or smoking for at least 15 minutes prior to an oral temperature measurement (Mackowiak et al., 1992). Axillary temperatures are said to be extremely inaccurate. Others claim it is as accurate as temperatures from other locations, if properly done: lie still, keep arm tight, and wait exactly 10 minutes (H. Nehrlich, *personal communication*, 2007).

Although the scientific literature has adopted the convention of expressing temperatures in degrees Centigrade, many clinical thermometers are still calibrated in degrees Fahrenheit. The conversion formula is $T°F = 9/5\ (T°C) + 32$; or, $T°C = 5/9\ [(T°F) - 32)]$.

Accuracy of Thermometers

The mercury thermometer is the gold standard for accuracy. Once calibrated, it is always calibrated. If manufacturing standards are lax, however, a new thermometer is not necessarily calibrated accurately. With one batch of 24 cheap thermometers imported from China, the temperature reading of a 37.0°C water bath ranged from 36.7°C to 37.2°C (mean = 36.96°C, SD = 0.15). Three readings of the temperature of the bath agreed to within 0.1°C with 15 thermometers and 0.3°C with 5. Two thermometers had a mercury column that collapsed immediately upon removal from the bath, and two developed this problem after two uses (N. Robinson, *unpublished observations*, 2003).

Glass thermometers have vanished from most hospitals and clinics. Besides the inconvenience of the time needed for equilibration and the risk of infection even if a plastic sheath is used, the breakage rate is high.

Infrared tympanic thermometers, though widely used because of convenience and speed, have been shown by some to be unreliable in clinical practice. Sensitivity for fever detection in both children and adults is as low as 55% to 70%. It has been found that subjective assessments by mothers were more sensitive for detecting fever than the infrared tympanic thermometers used in hospital emergency departments. Sequentially measured right and left ear temperatures have not uncommonly differed by as much as 1°C (Modell et al., 1998). Ear canal occlusion by cerumen has been found in one study, surprisingly, to have no effect on the measured temperatures (Modell et al., 1998) and, in another, to make tympanic temperature measurements even less reliable (Abolnik, 1999).

Although the infrared tympanic thermometer is supposed to measure core temperature, simultaneously measured oral temperatures were frequently higher in one study in which the difference between the two temperatures was ≥1°F (Abolnik, 1999).

In nonintensive care–hospitalized adult patients, the 95% limits of agreement for oral electronic versus tympanic membrane temperatures were −2.11°F to +2.81°F (Manian and Griesenauer, 1998).

Others have reported more encouraging results. Excluding patients with complete occlusion of the ear canals with cerumen, Smitz et al. found "acceptable" sensitivity and specificity for predicting rectal fever in older hospital inpatients. The correlation coefficient between rectal and infrared emission detection (IRED) ear temperatures was 0.78. With 37.2°C (99°F) selected as the fever threshold for IRED temperatures, the sensitivity was 86%; the specificity, 89%; the positive predictive value, 80%; and the negative predictive value, 93%. The sensitivity dropped to 50% when the fever threshold was raised to 37.6°C. In 3 of 45 patients, the difference in IRED and rectal temperatures exceeded 1°C. The authors cautioned that selective brain cooling might occur during hyperthermia, especially in dehydrated patients (Smitz et al., 2000). It is important to remember that these investigators used calibrated thermometers, examined the ears, and used the highest of six measurements.

With a single calibrated instrument, tympanic membrane temperatures in adult ICU patients correlated well with pulmonary artery temperatures ($r = 0.909$) (Klein et al., 1993).

The single use chemical thermometer was found to be more accurate than the mercury thermometer in a laboratory and a clinical setting (Blumenthal, 1992).

This author suggests that students calibrate the instrument they always have with them—the back of their hand—against readings of known accuracy.

Factitious Fever

Factitious fever may be produced by the patient surreptitiously applying heat to the (mercury) thermometer. If factitious fever is suspected, the patient should be observed throughout the process of taking the temperature. Patients have been known to switch glass thermometers, substituting a preheated one, so the serial number on the original thermometer should be noted (Murray, 1979). The technique of holding hot liquids in the mouth before the temperature taking could be foiled by measuring the rectal temperature. Another method is to use an electronic thermometer to measure the temperature of the urine as it is voided. Data and nomograms are available (Murray et al., 1977). If the oral temperature is 38°C, the expected urine temperature is 37.3°C (lower 99% confidence limit = 36.15°C). For an oral temperature of 39°C, the comparable figures are 38.15°C and 36.95°C. Thus, if the patient's measured oral temperature is 40°C and the urine temperature is only 37.7°C, one should suspect factitious fever.

Factitious fever is to be distinguished from factitious infection in which fever is a secondary but genuine phenomenon.

As mercury thermometers vanish, so too should this condition.

Normal Temperature

The figure of 98.6°F (37°C) as the upper limit of normal for temperature is credited to the 19th century investigator Carl Wunderlich, who reportedly analyzed more than 1 million axillary temperature readings from 25,000 individuals. He found a mean temperature of 98.6°F (37°C), with a range from 97.2°F (36.2°C) to 99.5°F (37.5°C). The minimum occurred between 2:00 and 8:00 AM and the maximum between 4:00 and 9:00 PM. He considered temperature readings in excess of 100.4°F (38°C) to be "suspicious" and "probably febrile." He thought that women had slightly higher temperatures and exhibited greater and more sudden changes than men, that there might be racial differences in body temperature, and that old people had a temperature about 0.9°F (0.5°C) less than young persons. Recent tests conducted with one of Wunderlich's instruments suggest that it may have been calibrated as much as 1.4°C to 2.2°C (2.6°F to 4.0°F) higher than today's instruments (Mackowiak, 1998), casting doubt on some cherished dictums about the special significance of 98.6°F or 37°C.

In the 1930s and 1940s, Barnes, in exploring the hypothesis that basal temperature mirrored the basal metabolic rate, found that the normal axillary temperature ranges between 97.8°F and 98.2°F (Barnes, 1942).

A modern study of 700 temperature readings in 148 healthy volunteers found a mean oral temperature of 98.2°F (37°C) and suggested that the upper limit of normal for the oral temperature be regarded as 98.9°F (37.2°C) in the morning and 99.9°F (37.7°C) overall. Investigators corroborated Wunderlich's opinion that women have a slightly higher normal temperature (Mackowiak et al., 1992).

Wunderlich wrote that the diurnal variation in normal temperature is 0.9°F (0.5°C). This was recently corroborated by one investigator who took his own oral temperature every 5 minutes for a day, finding that it fluctuated over a range of 97.3°F to 97.9°F (N. Robinson, *unpublished observations*, 2003). Mackowiak found daily oscillations as wide as 2.4°F (1.3°C). There is also a cyclical variation in ovulating women, with the early morning temperature (taken with the patient still in bed, just after awakening) dropping slightly just before the onset of menstruation. There may be a further drop just prior to ovulation, followed by a rise coincident with ovulation. Thereafter, the temperature remains at that level until just prior to the next menstruation. Careful monitoring of basal body temperature has been used in natural family planning but is much less reliable than currently available methods for detecting hormonal changes.

Measurement of the basal metabolic temperature has been suggested as a sensitive screening test for posttraumatic hypothyroidism, even when standard laboratory tests may be normal (Sehnert and Croft, 1996).

With available and affordable technology, it should become possible to transmit frequent measurements of vital signs to a home computer to monitor for patterns indicative of developing illness. In addition to the early detection of infection, obvious indications that could be monitored include changes in pulse rate or regularity as a premonitory sign of myocardial infarction or changes in respiration or heart rate in infants vulnerable to sudden infant death syndrome. Remarkably, there are no studies of diurnal variations in these basic physiologic variables in normal subjects to serve as a baseline, as far as this author has been able to determine.

Fever

An elevation in temperature is usually a sign of an infectious or inflammatory condition, although it may also result from thyrotoxicosis, heat stroke, neoplasia, drugs, and many other entities. Several fever patterns have been described. Relapsing fevers have afebrile days alternating with days of fever. Diseases characterized by relapsing fevers include familial Mediterranean fever; brucellosis in which the fever is associated with physical activity and disappears on days of bed rest; Hodgkin disease; *Borrelia* infections; tuberculosis, especially extrapulmonary; and malaria.

The Pel–Ebstein relapsing fever of Hodgkin disease occurs in about 16% of cases and is quite variable. It may last for hours to days, followed by days or weeks without fever.

The fever pattern in malaria may indicate the organism involved. Tertian fevers return on the third day and so have a periodicity of 48 hours. They signify infection with *Plasmodium vivax* or *P. ovale*. Quartan fever is one that returns on the fourth day and so has a 72-hour periodicity. It is seen with *P. malariae*. A double quartan fever returns every other day, but the recurrences are alternately severe and mild. Triple quartan fever results from infection with three different strains of *P. malariae*, resulting in daily (quotidian) fever. (Of course, not all such fevers are due to malaria.)

A double quotidian fever occurs twice a day and is seen in about half the cases of gonococcal endocarditis.

A double-humped ("saddle-backed") fever curve (with two peaks during 1 week and a low-grade fever in the valley) is seen in some viral diseases such as West Nile fever, dengue, and Bornholm disease.

A remittent fever is one that falls each day but not quite to normal, remaining at 99.2°F (37.3°C) or above. An intermittent fever falls to normal or below each day. In remittent or intermittent fever, the excursion in temperature is more than 0.3°C (0.5°F) and less than 1.4°C (2.5°F). A hectic fever is a remittent or intermittent fever with a difference of 1.4°C (2.5°F) or more between peak and

trough. A sustained fever has a less than 0.3°C (0.5°F) fluctuation during a 24-hour period.

The latter four fever patterns are of minimal diagnostic value, as shown in a study of 200 patients with single episodes of fever (Musher et al., 1979). A sustained fever occurred frequently enough in cases of Gram-negative pneumonia and of central nervous system damage (and infrequently enough in other conditions) to suggest, but not establish, one of these two diagnoses. The absence of the usual diurnal effect (maximum temperature between 4:00 PM and midnight) supported but did not prove a noninfectious etiology, especially central nervous system damage. Impairment of hypothalamic control of temperature was thought to be the mechanism of the fever associated with central nervous system damage.

The most common hypothalamic fever is part of the hypnotic–sedative withdrawal syndrome. It appears only during acute abstinence and abates with treatment. Paroxysmal hypothalamic fevers occur in syndromes with other centrally mediated events such as insomnia, hypersomnia, hyperphagia, restlessness, and electroencephalographic abnormalities. When the fever abates, so do the associated findings. The condition is, fortunately, extremely rare because it is generally either overdiagnosed or underdiagnosed. Lesions in the posterior portion of the hypothalamus may be attended by hypothermia or poikilothermia, the latter possibly passing unnoticed unless the patient's temperature is taken after changing the room temperature. Somnolence and hypotension may also be associated with such lesions (Adams and Victor, 1981).

Extremely high fevers (in excess of 106°F or 41.2°C) are rarely attributable to infection, with the exception of central nervous system infections such as bacterial meningitis or viral encephalitis. In my own experience, heat stroke has been the most common cause. The temperature obtained with a regular thermometer may be a dangerous underestimate. Such patients should be monitored immediately with a thermistor placed high in the rectum, as aggressive cooling has begun.

Some central nervous system lesions cause a disturbance in the body's temperature regulation. After operations in the region of the floor of the third ventricle, the temperature may rise to 106°F or higher and remain there until death, hours or days later. Icy coldness of the extremities, dry skin, tachycardia, and tachypnea are also present (Adams and Victor, 1981).

Fever is usually accompanied by an increase in the pulse rate of approximately 10 beats per minute per degree Fahrenheit. With some infections, the pulse is characteristically slower than expected: salmonelloses (including typhoid fever), tularemia, brucellosis, bacterial meningitis complicated by increased intracranial pressure, mycoplasmal pneumonia, rickettsialpox, *Legionella* pneumonia, mumps, infectious hepatitis, Colorado tick fever, and dengue. A disproportionately low pulse may also be seen in factitious fever or in patients taking digitalis glycosides or beta-blockers.

For any rapidly changing variable, which moves widely about a mean (such as platelet count or temperature), a cusum (cumulative sums) plot will help you determine when a real change has taken place. To make such a plot, arbitrarily define a standard value, such as 100°F for the temperature. Make a list of the temperatures and of their deviations from the standard value and calculate the cusum, which is the cumulative sum of the deviations (Table 6.2). Plot the cusums on a graph (Fig. 6-9). The change point is the point at which there is a change in the slope. This may help you determine which antibiotic made a difference in the fever.

TABLE **6.2** *Temperatures and cusums*

Hourly temperature (°F)	Deviation	Cusum
100	0	0
102	+2	+2
99	–1	+1
104	+4	+5
99	–1	+4
103	+3	+7
101	+1	+8
98	–2	+6
99	–1	+5
101	+1	+6
99	–1	+5
101	+1	+6
102	+2	+7

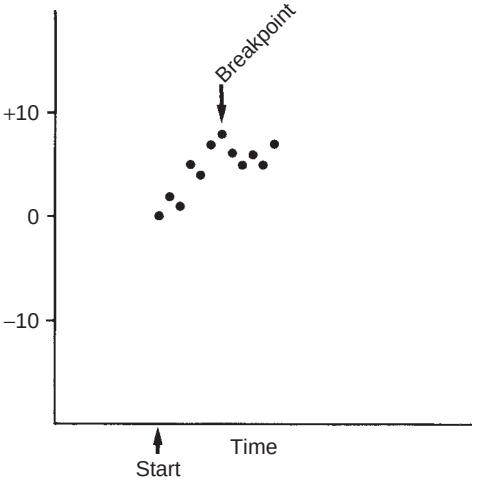

FIGURE **6-9** A cusum plot for temperatures.

Another technique is to record the maximum temperature for each 24-hour period.

The Physiologic Role of Fever

There is more to the physiologic response to fever than hyperthermia. In fever, as opposed to a failure of thermoregulatory homeostasis, the core temperature rise is mediated by cytokines and accompanied by the release of acute phase reactants and the activation of numerous immunologic and endocrinologic systems (Mackowiak, 1998). An inability to mount a fever when appropriate may signify a poor prognosis.

When examining or reporting on the course of a fever, be sure to consider whether antipyretics have been given. The proper use of such agents has been the subject of considerable controversy in recent years.

Hypothermia

Hypothermia is defined as an oral temperature of less than 95°F (35°C). Because routine thermometers do not read temperatures this low, it may be missed unless the examiner suspects it and checks the temperature with a thermistor.

Six specific causes of severe hypothermia are reversible and may require emergency treatment: hypoglycemia, hypothyroidism, hypoadrenocorticism, overwhelming infection (Bryant et al., 1971), intoxications, and exposure.

With a severe depression in body temperature, metabolic processes slow, and the patient may resemble a person with myxedema or may even appear to be dead. Hypothermia prolongs the time that a person may survive anoxia.

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CHAPTER 7

Integument

The skin of the coward changes colour one way and another.
—HOMER, *ILIAD*, XIII, 279

POINTS TO REMEMBER:

- Look *for* skin lesions, not just *at* them. Use a magnifying glass, and wipe the lesion with oil or alcohol to get a better look.
- Learn to describe the features of lesions precisely: distribution, color, size, thickness, whether solid or fluid-containing, presence and point of attachment of any scales, demarcation, pattern, symmetry.
- If one mole looks much different from all the others, biopsy or excise it.
- An agent that has been used for years can still cause an allergic contact dermatitis. The patient changes, even if the agent does not.
- The skin manifests many outward signs of what is occurring within, in patients with systemic disease.
- Examine the iris, conjunctiva, and eyelid rims. If you see one component of a systemic disease, look for others. For example, if there are café au lait macules, search the iris for Lisch nodules.
- Nail abnormalities may enable you to date a past insult.

Skin

The skin is the most accessible organ in the body, and it can provide many diagnostic clues for the examiner who knows what he seeks. The skin should be inspected methodically, with adequate exposure, preferably in direct sunlight. The texture should be felt and any lesions should be palpated, making careful observations of the details listed in Chapter 4.

It is not possible to give an exhaustive description of all the lesions that might be observed in the skin. We are not concerned with providing a compendium of dermatology but rather with providing a method for observing skin lesions. Some illustrations of skin manifestations of medical diseases will be presented. The sampling is chosen partly to illustrate epistemologic principles. *The student who has learned to observe and describe precisely what he has observed will then be able to make effective use of textbooks of medicine and dermatology or Internet sites with color illustrations, such as www.dermnetnz.org. Even if you have no clue about the etiology of a skin lesion, if you can describe it accurately, a dermatologist, with his highly developed pattern recognition skills, may be able to diagnose it over the telephone.*

A basic principle to remember: Look *for* skin lesions, do not just look *at* them.

When examining a lesion, use a magnifying glass, and wipe it with oil or alcohol to get a better look. Be sure the lighting is adequate and appropriate (*vide infra*).

It is absolutely critical to establish the basic morphology of the dermatologic condition. For example, the student must be able to answer questions such as these: Is the basic lesion solid (a papule) or fluid-containing (a vesicle)? If the lesion is scaling, what is the color of the scale, its thickness, and its point of attachment (central, peripheral, or diffuse)? Is the lesion sharply demarcated from the surrounding skin, or does it blend gradually into its surroundings? What is the distribution of the lesions or eruption? Is the condition symmetrical or asymmetrical? Are any areas noticeably spared? The pattern of the lesions and the parts of the body involved (or not involved) are often of great diagnostic significance.

Dermatologic findings fairly specific to one region of the body are found in the "inspection" portion of appropriate chapters (e.g., pretibial myxedema, erythema nodosum, and some other skin lesions usually associated with the pretibial region are described in Chapter 24).

The terms used to describe the morphology of skin lesions are listed in Table 7.1.

If you see one component of a systemic disease in examining the integument, look for others, especially in the iris, conjunctiva, and eyelid rims.

Color

Diffuse Pigmentation

In whites, pay particular attention to the abdomen, which has been protected from the sun. The excess pigment will be more obvious there, although it may *not* be as pronounced as in the sun-exposed areas. Pressure points, such as the belt line, will often show an exaggeration of pigmentation due to a chronic process. Be sure to check the mucous membranes.

The most common cause of diffuse endogenous pigmentation is jaundice (also see Chapter 10). A diffuse brown hyperpigmentation may occur in some patients with melanoma. Diffuse hyperpigmentation may be present in advanced cases of the acquired immune deficiency syndrome (AIDS) and may be accentuated by antiretroviral therapy. Progressive systemic sclerosis is also stated to cause diffuse pigmentation, but this occurs only when the skin lesions are truly diffuse, by which time there is little diagnostic challenge. Generalized hyperpigmentation, accentuated in flexural areas, together with discrete macules on the palms and soles, can occur with vitamin B_{12} deficiency (Greenfield and Gregory, 1998).

Diffuse hyperpigmentation is a feature of chronic adrenocortical insufficiency or other states characterized by chronically high levels of adrenocorticotropic hormone (ACTH), such as the so-called *ectopic ACTH syndrome*, a paraneoplastic syndrome in which the tumor makes huge amounts of pro-ACTH along with the carboxypeptidase to cleave it.

TABLE **7.1** *Terms used to describe the morphology of skin lesions*

Primary lesions	*Special lesions*
Macule	Comedo (pl. comedones)
Papule	Milium (pl. milia)
Plaque	Telangiectasis
Nodule	Target lesion
Cyst	
Wheal	*Descriptive terms*
Vesicle	Hypopigmented
Bulla	Hyperpigmented
Pustule	Erythematous
	Purpuric
Secondary lesions	Scaling
Crust	Hypertrophic
Erosion	Atrophic
Excoriation	Lichenfied
Ulcer	Indurated
Scar	

From Moschella SL, Hurley HJ. *Dermatology*. 2nd Ed. Philadelphia, PA: W. B. Saunders, 1985, with permission.

Historic Note. Thomas Addison had an abiding interest in dermatology. In 1855, his ascription of hyperpigmentation, weakness, and nervous irritability to disease of the suprarenal glands, mystery organs of the time, was an amazing feat of inductive reasoning. His original series contained six patients on whom autopsies were performed (Herman, 1997). Serendipity and his faithful younger colleague Samuel Wilks, to whom it was more important to discern and promulgate truth than to take credit, also played a vital role (Graner, 1987).

A pale yellow color not simply due to anemia is seen in pernicious anemia (because of indirect bilirubin from intramedullary hemolysis), in some cases of myxedema (because of carotene), and in some cases of the nephrotic syndrome (because of urochrome and carotene). This color is not so striking in simple chronic uremia, which also has the pallor of anemia. In nephrotic syndrome, the hypoalbuminemia is accompanied by a compensatory hyperglobulinemia, including an increase in the carotene-binding globulin. (However, hypercarotenemia does not occur in cirrhosis, presumably because of a concurrent problem with hepatic metabolism.)

In hemochromatosis, the skin is grayish or bronze or appears dirty.

I once saw a family in which the children suffered a green coloration of the skin, occurring maximally about 30 minutes after exercise. I assumed that the exercise produced hemolysis and deduced that there must have been a congenital defect in biliverdin reductase because biliverdin would be the only green substance that could be endogenously produced in sufficient quantity to color the skin. I was not able to persuade the doctors in charge to perform the proper studies to test this hypothesis. Still, such cases are a useful reminder that the book is not closed on unusual skin pigmentations.

Various drugs or poisons can induce a diffuse hyperpigmentation. Examples include atabrine (which causes a yellowish color), phenol, busulfan, and heavy metal poisoning. Unlike adrenal cortical insufficiency, which causes diffuse pigmentation of the mucous membranes, heavy metals (mercury, lead, arsenic, and bismuth) are deposited along the gingival margin (see Fig. 13-5). Antimalarials may produce pigmentation of the palate. The silvery blue-gray pigmentation of argyria is so striking that once seen it is never forgotten. Patients are sometimes called "cyanotic." With the popularity of "colloidal silver" in alternative medicine circles, we could see an increase in this condition. Colloidal silver may be recommended as anthrax prophylaxis (Hori et al., 2002) or for treatment of AIDS, colds, diabetes, herpetic infections, or cancer (Gulbranson et al., 2000; White et al., 2003). An excessive melanin deposition can occur after many years of high-dose chlorpromazine therapy because of the photosensitizing and melanin-binding effect of phenothiazines. About 2% to 5% of patients taking amiodarone develop hyperpigmentation. In both cases, the pigment is more dirty gray than brown. Drugs, e.g., minocycline and amiodarone, can also induce focal hyperpigmentation (T. Rosenwasser, *personal communication*, 2009).

A striking yellow or orange pigment, most noticeable in the palms or soles, can occur with ingestion of excessive amounts of carotene-containing foods or with isoretinoin or rifampin overdose. Food faddists who eat massive amounts of tomatoes develop the red-tinted lycopenemia. In both, the skin is tinted more than the scleral conjunctivae.

Focal Hyperpigmentation

Pigmented streaks, blotches, or spots may appear on the buccal mucosa and on the tongue in chronic adrenocortical insufficiency, in addition to the diffuse hyperpigmentation. Scars also become hyperpigmented in chronic adrenocortical insufficiency.

Acanthosis nigricans is discussed later in this chapter. The skin signs of pregnancy are included in Table 22.2.

Hyperpigmentation on the lower leg, associated with edema, dermatitis, and induration, is a feature of venous stasis and the postphlebitic syndrome. Diabetic dermopathy, the most common skin sign of diabetes, starts with dull red papules that progress to form small, well-circumscribed atrophic hyperpigmented patches in the pretibial area.

Hyperpigmented sometimes callused patches above the knees (the Dahl sign, Fig. 7-1A) may be seen in chronic obstructive lung disease (Dahl, 1970). They are produced by the patient's posture (Fig. 7-1B), a common one in patients with chronic obstructive lung disease because such bracing of the musculoskeletal bellows improves the efficiency of the muscles of respiration (see Chapter 5).

Either hyperpigmentation or hypopigmentation may occur as a result of chronic trauma, as on the left long (pleximeter) finger of an octogenarian internist who had practiced mediate percussion (see Chapter 16) for more than 62 years (Adams and Gore, 1997).

Ochronosis primarily affects cartilage, especially that of the ears. It is more brownish or yellowish than other pigmented states, hence the name, which derives from ocher. It usually begins as a blue or blue-gray coloration of the pinnae. The tip of the nose, sclerae, costochondral junctions, and extensor surfaces of the hands may also be involved (J. Scherzer, *personal communication*, 1998).

"Porphyria" is stated to cause pigmentation; however, the types that do so are also associated with hypersensitivity to light, such as

A B

Figure 7-1 **A:** Hyperpigmented patches above the knees in a patient with chronic obstructive lung disease (the Dahl sign). This patient reported that his father, who also suffered from chronic obstructive lung disease, had similar patches. **B:** Typical posture of such patients. Self-test: What other diagnoses can you make from these pictures? (See Appendix 7.1.) (Photographs courtesy of Dr Gretchen Meyer of California, with permission.)

porphyria cutanea tarda, in which hyperpigmentation may develop on the exposed areas of the hands and upper chest. The skin abrades and blisters easily and may also show healed depigmented scars over the exposed areas, such as the hands (see Fig. 25-2).

Diffuse hyperpigmentation of skin that is taut and thickened occurs in the Crow–Fukase (POEMS) syndrome (*vide infra*).

Erythema

Erythema means "redness" and can occur as a generalized phenomenon in vasodilatory states (such as scarlet fever), or it may be localized (also see "Exanthems" later in this chapter). The erythema may be followed by exfoliation, as in staphylococcal scalded skin syndrome.

An erythema resembling sunburn is the first skin sign of pellagra. The skin lesions tend to be symmetric and localized over exposed areas. In addition, the scrotum, vulva, and perianal area may be involved, especially as dementia and diarrhea supervene. The skin later develops vesicles or peeling, a dirty brown color, and a rough scaly texture.

The "red neck syndrome," also called the "red man syndrome," may result from a too rapid infusion of vancomycin, among other causes (e.g., Sézary syndrome [see "Metastatic Tumors," later in this chapter], or from histamine release as from intravenous codeine administration).

Conditions causing malar erythema are discussed in Chapter 9 (see Fig. 9-9).

A pink discoloration of the fingers and toes, desquamation of the palms and soles, and a morbilliform rash are dermatologic manifestations of mercury poisoning. Pink disease, or acrodynia, was once a common, sometimes fatal, disease in infants before mercury was removed from teething powders, diaper rinses, and laxatives. Other sources of mercury exposure included repeated gamma globulin injections, fungicides in paint, mercurial antibacterial ointments, and ingestion of watch batteries. Accompanying manifestations include flushing; irritability; swollen, painful fingers and toes; weakness; tachycardia; elevated blood pressure; photophobia; and polyneuritis. Delayed appearance of symptoms may complicate recognition of the cause. The medical profession's resistance to acknowledging the evidence of the toxicity of mercury has lessons for contemporary medicine (Dally, 1997).

The cherry red color of carboxyhemoglobinemia (*vide infra*) persists for some time but may be gone by the time the patient is seen. Thus, do not rule out carbon monoxide poisoning because of its absence. Instead, be alert to tip-offs such as headaches and giddiness and the increased risk accompanying cold weather and power outages.

Cyanosis

Cyanosis means "blue colored." Generalized cyanosis is caused by deoxyhemoglobin, methemoglobin, or sulfhemoglobin. The first is generally the result of insufficient oxygenation because of shunting, hypoventilation, or ventilation/perfusion mismatch. Methemoglobinemia and sulfhemoglobinemia result from drug exposure and/or certain congenital metabolic abnormalities.

In order to get cyanosis due to deoxyhemoglobinemia, there must be at least 5 g per dL of unsaturated hemoglobin (deoxyhemoglobin). Thus, an anemic patient with only 5 g per dL of hemoglobin cannot become cyanotic. With 7.5 g per dL of hemoglobin, a patient would have to be 67% unsaturated to show the same bluish color as a patient with a normal hemoglobin (15 g per dL) and 33% unsaturation. (This does not hold for methemoglobinemia and sulfhemoglobinemia, which cause cyanosis at 1.5 g per dL and 0.5 g per dL, respectively. Also, of course, it does not hold for carboxyhemoglobinemia due to carbon monoxide poisoning, which never causes cyanosis even as the patient succumbs to cellular anoxia.)

The presence of cyanosis is often recorded under "general appearance" in the physical examination, rather than under "integument." If restricted to the extremities, it might also be in that section. (See nail beds for acrocyanosis, discussed later in this chapter.)

Differential cyanosis refers to the appearance of cyanosis in both lower extremities (and sometimes the left upper extremity—"harlequin" cyanosis) with a pink right upper extremity. This is seen in patent ductus arteriosus, when secondary pulmonary hypertension has supervened. The cyanotic blood in the pulmonary artery then goes through the patent ductus arteriosus, empties into the aorta, and flows to the lower half of the body. The upper half of the body continues to get oxygenated blood from the left ventricle. If the patent ductus enters the aorta below the left subclavian artery, the left arm is pink; if it enters above the left subclavian artery, the left arm is blue.

This lesion initially has the cardinal sign of a continuous "machinery" murmur in the second left intercostal space (Gibson murmur, see Chapter 17), which is so characteristic that few books also mention the differential cyanosis. However, if the diagnosis is initially missed, the unoperated patient develops pulmonary hypertension and the shunt reverses direction. The murmur is now altered, and the sign of differential cyanosis appears. In practical terms, the appearance of the latter finding means that it is now too late to operate on the patient.

In reverse differential cyanosis, the arms are more cyanotic than the legs. This is caused by transposition of the great vessels with ventricular septal defect and patent ductus arteriosus. (In this condition, both the pulmonary artery and the aorta arise from the right ventricle, causing the cyanosis.) Oxygenated blood from the left ventricle can cross the ventricular septal defect into the right ventricle and the pulmonary artery, which sits just above the septal defect. When pulmonary hypertension supervenes, this oxygenated blood flows back through the patent ductus arteriosus into the descending aorta, "pinking up" the feet (Perloff, 1982).

Differential cyanosis due to other vascular lesions, including dissecting aortic aneurysm, is discussed in Chapter 18.

Livedo reticularis, which is Latin for "skin discoloration in the form of a small net," is usually found on the extremities but possibly on the trunk. The mottled or netlike reddish to blue discoloration, without discrete borders, is often more prominent after cold exposure.

True livedo reticularis might be a sign of a collagen vascular disease such as polyarteritis nodosa, dermatomyositis, rheumatoid arthritis, and systemic lupus erythematosus (and, by extension, Raynaud "disease," if this entity exists—see Chapter 18 for an epistemologic discussion). Or it may be seen in association with pancreatitis, shock, or bacterial endocarditis (Bishop et al., 1981). It may occur with leg ulcers or as part of congenital phlebectasia (Fitzpatrick et al., 1979) or Sneddon syndrome (Levine et al., 1988). Additionally, it can occur with relapsing polychondritis, embolic phenomena, Parkinson disease, and certain drugs including levodopa (Moschella and Hurley, 1985). In women, the triad of livedo reticularis, dementia (due to multiple isolated strokes), and multiple miscarriages suggests the anticardiolipin syndrome (D. Printz, *personal communication*, 1998).

A Note for Sophomores. The list is not exhaustive, nor is it meant for memorization. The underlying message is that this finding, like many others, has an extensive differential diagnosis, which you cannot begin to consider unless you first recognize the sign!

Livedo reticularis may be confused with *cutis marmorata* (literally, "marbled skin"), which might or might not have bright pink splotches between the blue-purple lines. Unlike livedo reticularis, cutis marmorata characteristically appears in response to cold and disappears with warming and has no strong associations with serious disease.

Livedo reticularis may also be confused with *erythema ab igne*, which literally means "redness from the fire." Again, there is a netlike appearance, but *erythema ab igne* is not blue-purple but red or, when chronic, simply pigmented. It results from chronic exposure of the limb to heat, for example, from a fireplace (especially when seen over the legs) or from a heating pad (Bean, 1976).

Vitiligo

Vitiligo is a condition manifested by white spots and patches on the skin. It begins before age 18 in half the patients. Usually, the hands, feet, or face are affected first. Like a forest fire, the process of death of the pigment cells spreads and then burns out.

An associated autoimmune endocrine disorder, such as thyroiditis, diabetes mellitus (Dawber, 1968), or chronic adrenocortical insufficiency, is found in about 20% to 30% of patients with vitiligo. Perhaps another 25% have elevated serum levels of one of the autoantibodies associated with such a disease, although not the disease itself.

Vitiligo is also seen in association with multiple myeloma, Hodgkin disease, mycosis fungoides, autoimmune hemolytic anemia, dysgammaglobulinemia, and mucocutaneous candidiasis, as well as in some melanoma patients who have metastases (Nordlund and Lerner, 1982).

The occurrence of vitiligo with anterior uveitis (iritis), poliosis (premature graying of some or all of the hair), alopecia, and/or dysacusia (the experience of pain caused by certain sounds) is Vogt–Koyanagi–Harada syndrome (Nordlund and Lerner, 1982). Such patients may also have posterior uveitis (chorioretinitis).

Various causes of amelanosis and hypomelanosis are listed in Table 7.2.

Fluorescence

Examination under Wood's ultraviolet light reveals fluorescence in some lesions (e.g., a golden color due to tinea versicolor, coral red due to erythrasma, or green due to a *Pseudomonas* infection, especially in burns).

Telangiectasia

"Telangiectasia" is Greek for "dilatation of the ends of the vessels." Like a foolish parrot, I repeated for years the error that I had been taught: the "tel" comes from the Latin meaning "woven, like a web." In fact, there is nothing at all weblike in the telangiectasia seen in the CREST variant of scleroderma (see Chapter 24) or the red spots of hereditary hemorrhagic telangiectasia (Osler–Weber–Rendu disease). The latter are located on the fingers, tongue, and mouth. They resemble cherry angiomas (see "Cherry Angiomas," later in this chapter), except for the distribution and the fact that the latter are raised.

Spider telangiectasias (Bean, 1958) are arterial telangiectasias appearing in the region drained by the superior vena cava (the chest

TABLE **7.2** *Types of hypomelanosis and amelanosis*

Scattered, discrete, various sizes
Vitiligo
Hyperthyroidism
Addison disease
Pernicious anemia
Hypoparathyroidism and Addison disease (polyglandular autoimmune syndrome type I)
Vogt–Koyanagi—Harada
Tuberous sclerosis
Tinea versicolor
Leprosy (tuberculoid)
Postinflammation depigmentation
Psoriasis
Atopic dermatitis
Pityriasis alba

Segmental, in quasi-dermatomal pattern
Vitiligo
Nevus depigmentosus
Tuberous sclerosis

From Fitzpatrick TB, Eisen AZ, Wolff K, et al., eds. *Dermatology in General Medicine.* 2nd Ed. New York: McGraw-Hill, 1979, with permission.

Figure 7-2 Telangiectasia on the nose. (Photograph courtesy of Dr Joseph Scherzer of Scottsdale, Arizona, with permission.)

and upper arms). They appear to have legs radiating spiderlike out from a body. The body is actually the central arterial supply of the lesion, as can be shown by a simple bedside diagnostic test. If a glass slide is placed on top of the spider, the pressure can be gradually increased to a point at which the spider will blanch only during diastole and will be seen to pulsate in time with the heartbeat. If the lesion is blanched completely and the pressure is gradually reduced, the central spot will fill with blood first. Conversely, the entire spider can be made to blanch by exerting pressure on the central arterial supply with either a pencil point or the edge of the glass slide. (A little immersion oil sometimes makes it easier to see the pressure phenomena.)

Spider telangiectasias are usually considered a sign of hyperestrogenism, either physiologic as in a pregnant woman or pathologic as in a cirrhotic man (Bean, 1958).

Telangiectasia involving the ears, neck, and flexor creases at the elbows and knees (as well as the bulbar conjunctiva) is a sign of ataxia telangiectasia, one of the neurocutaneous syndromes or phakomatoses (see Table 10-23).

Figure 7-2 shows telangiectasia on the nose.

Lesions Due to Bleeding Problems

Petechiae

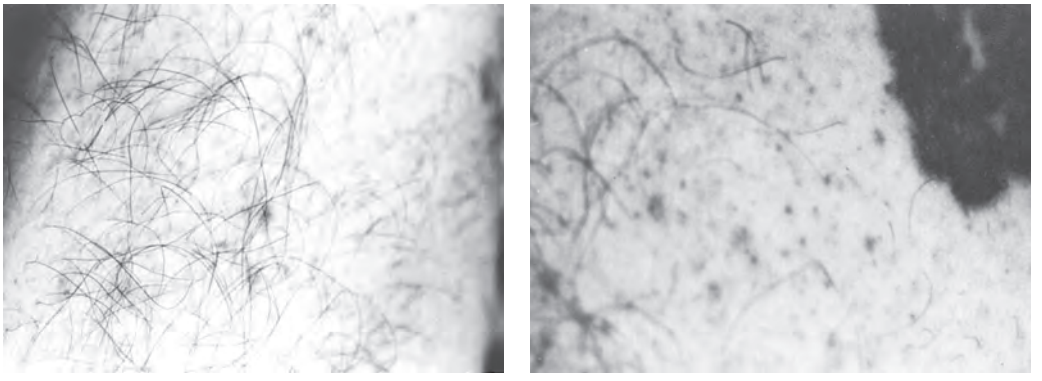
A petechia is a small red hemorrhage (Fig. 7-3), which does not blanch with pressure. Various sources describe the size as being pinpoint (<1 mm) to up to 4 mm. Petechiae signify a capillary or platelet disorder, although the involvement of the capillary may be only secondary—for example, to endocarditis or fat embolism.

The occurrence of petechiae in a wide range of disorders suggests that more than one pathogenetic mechanism may be involved, with the common final result of endothelial injury. Mechanisms may include mechanical disruption, hypoxia (in association with some degree of venous obstruction), barotrauma, or toxins (Jaffe, 1994).

A common and conspicuous finding in forensic examinations, petechiae were first described in 1855 by pathologist Ambroise August Tardieu, who considered them to be of absolute diagnostic significance in asphyxial states (Jaffe, 1994).

The initial clinical description of the triad of confusion, dyspnea, and petechiae seen in fat embolism due to trauma appeared in the German literature in the late 1800s (Pollock, 1979). Skin petechiae are actually found in only about half of the patients with fat embolism and, in some series less than one fourth, depending upon the criteria used for diagnosis (i.e., clinical or autopsy). This holds even for series reported from the same institution (Dines et al., 1975; Thomas and Ayyar, 1972). But the same sort of prevalences also occurs for conjunctival petechiae, retinal findings, and lipiduria. Far from diminishing the importance of petechiae, this emphasizes their diagnostic utility as part of a systematic search for findings. In the proper clinical setting, the presence of petechiae is virtually diagnostic of fat embolism (Kaplan et al., 1986).

Conditions associated with petechiae that are probably secondary to disseminated intravascular coagulation include amniotic fluid embolism and other obstetric emergencies; septicemia, especially meningococcal; hypothermic or hyperthermic states; and shock



A B

FIGURE 7-3 Petechiae. **A:** The little speckles beneath the hairs are slightly out of focus to remind you that in real life you must actively search for them. **B:** These petechiae are easier to see because there is less hair in the way. The large dark spot is a coincidental tattoo. This patient had prostatic carcinoma invading his marrow, causing thrombocytopenia. The petechiae were important in drawing attention to his platelets because he had other explanations for his presenting epistaxis and hematuria.

from any cause (Jaffe, 1994). In the preantibiotic era, petechiae were found in 29% to 88% of patients with bacterial endocarditis. In the postantibiotic era, the prevalence is said to be 19% to 40% (Bishop et al., 1981).

Petechiae have been described in diagnosed (Swank, 1958) or probable multiple sclerosis (James, 1982) and have been observed by this author. Swank stated that nontraumatic subcutaneous hemorrhages, especially in the legs, were observed in 48 of 62 female patients over 5 to 9 years of observation and seemed frequently to precede or coincide with exacerbations of the disease. Dr James considers these observations to be evidence of subacute fat embolism as a causative mechanism for multiple sclerosis.

The perifollicular hemorrhages of scurvy (see Fig. 7-32), which occur in up to 84% of cases, are often mistaken for petechiae (Vilter et al., 1946), which also occur in scurvy.

A Method

The Rumpel–Leede test is a provocative bedside test for capillary disease or platelet dysfunction.

1. In the middle of the flexor surface of the forearm, about 4 cm distal to the antecubital fossa, outline in ballpoint pen a U.S. quarter (2.5 cm in diameter).
2. Place the sphygmomanometer cuff around the biceps of the same arm, and pump the cuff up to halfway between the systolic and diastolic blood pressures. Keep it inflated for 5 minutes.
3. Count the number of petechiae that appear within the circle. Normal is five or fewer for men and ten or fewer for women and children.

To improve the results of the Rumpel–Leede test in cases of scurvy, delay the reading of the petechiae for 30 minutes (Vitamin C Subcommittee, 1953).

Very impressive petechiae have been seen in patients with osteogenesis imperfecta, even with normal bleeding times, demonstrating the increased capillary fragility in this condition (Evensen et al., 1984).

(For other bedside studies of platelets and platelet function, see "blood clot tests" and "platelets" [Chapter 28].)

Ecchymoses

An ecchymosis is also a bloody extravasation, distinguished from a petechia by its size, which is greater than 1 mm. Ecchymoses generally signify large-vessel bleeding from trauma or clotting factor deficiency, although they may also result from a confluence of petechiae that turn purple.

Bruises should not be confused with Mongolian spots, which are gray-blue lesions seen in dark-skinned children, mostly over the lower back and buttocks. They are present at birth and fade over months to years. These spots have led to an erroneous diagnosis of child abuse (Stewart and Rosenberg, 1996b).

There are several types of ecchymosis that are considered pathognomonic: (a) an iatrogenic ecchymosis caused by subcutaneous heparin or insulin administration in the anterior abdominal wall, (b) the paramalleolar ecchymosis due to a ruptured popliteal cyst (see Fig. 24-11), (c) the Battle sign and raccoon eyes (see Fig. 9-1), (d) signs of intraperitoneal bleeding (the Grey Turner sign and the Cullen sign, Chapter 20, and the Bryant sign, Chapter 23), (e) the finding shown in Fig. 7-4 (can you make the diagnosis?), and (f) the confluent ecchymoses of scurvy (see Fig. 7-5).

Corticosteroid therapy may cause "steroid bruising," especially over the forearms. If the patient has not been forewarned, this can be a source of anxiety.

In scurvy, the ecchymoses begin with follicular hyperkeratoses, which develop petechiae that enlarge and become confluent.

In one study of experimental scurvy in a surgical resident (Crandon et al., 1940), the petechiae and ecchymoses began on the lower legs, but in another study of full-time volunteers (Vitamin C Subcommittee, 1948), the petechiae began on the trunk and upper arms. A solid mass of ecchymoses in the "saddle distribution" (back of the legs, buttocks, and perineum) is characteristic: an empiric observation (see "Definitions" in Chapter 1) that is not

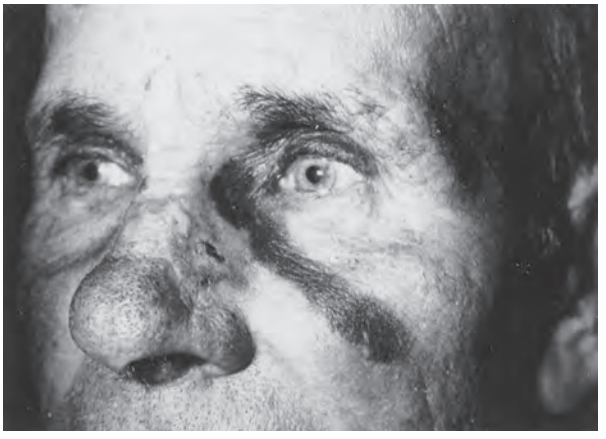


FIGURE 7-4 This suborbital ecchymosis is the first of the several types of ecchymosis that permit a specific diagnosis. Dr David Dobmeyer of Missouri reported that this patient was placed in the knee–chest position for a sigmoidoscopy, and the examining table was tilted so that the patient's head remained dependent for a considerable period of time. The medical student was the first to notice the ecchymosis, and because he had prepared himself by reading about the patient's underlying disease, he was able to explain the finding. The cause of this pathognomonic ecchymosis was the increased capillary fragility of the periorbital tissues, which enabled the increased venous pressure from the head-down position to produce the lesion. Can you make the diagnosis? (The answer is in Appendix 7.2.) This ecchymosis must be distinguished from "raccoon eyes" (see Fig. 9-1B).

yet understood. Up to 90% of scorbutic patients have petechiae and ecchymoses (see Fig. 7-5), not necessarily restricted to the saddle region (Vilter et al., 1946).

Modern-day Scurvy

Although scurvy is thought to be rare, it is not. It is simply unrecognized. I saw two cases and was shown two more in a 10-month period while this chapter was in preparation. Do not omit the dietary history; this author saw a case of scurvy in a "psychiatric patient" whose diet consisted almost entirely of margarine.

Infantile scurvy or Barlow disease was an uncommon but well-recognized condition among bottle-fed infants in the first half of the 20th century in New Zealand. The diagnosis went out of fashion, but the disease still occurs and can easily be mistaken for nonaccidental trauma or child abuse (Clemetson, 2004). The presentation may be atypical. Scurvy should be in the differential diagnosis of *any* bleeding manifestations in a young child. A detailed dietary history is mandatory in pediatrics. Keep in mind that human milk contains five times more vitamin C than cow's milk (Ahuja and Karande, 2002). A therapeutic trial of vitamin C can have dramatic results.

Scurvy is a rare complication of anorexia nervosa, although in this condition, poor intake of nutrients does not commonly lead to manifestations of vitamin deficiency (Christopher et al., 2002).

Scurvy must be diagnosed clinically and not by the laboratory. Serum ascorbate levels may be zero weeks before the disease appears (Crandon et al., 1940), while some patients with the disease have had measurable serum and leukocyte ascorbate levels (Thomas et al., 1984). Furthermore, leukocyte ascorbate levels equivalent to those found in patients with scurvy may be found in 3% of healthy elderly persons and in 20% to 50% of hospitalized and institutionalized patients (Cheraskin, 1985). (This raises the question of whether unrecognized scurvy is much more common than generally believed.) Urine levels are only helpful if performed as part of the ascorbic acid–loading test, but you have to make the diagnosis clinically before ordering that test.

The diagnosis of scurvy was missed for nearly 3 weeks at the Massachusetts General Hospital in a patient with confluent purpuric lesions, prominently involving the saddle region, although the patient had been "screened by a nutritionist" (Meisel, 1996). Blood and leukocyte ascorbic acid levels were normal after 20 days of repletion of vitamin C with a daily multivitamin tablet containing

A B

FIGURE 7-5 A patient with scurvy. In this patient, the "saddle" is relatively free of ecchymoses when compared with the lower extremities, which show huge confluent hemorrhages. See Fig. 7-33 for another sign of scurvy.

60 mg ascorbic acid. By that time, the skin lesions were resolving. The patient, as his physicians eventually determined, lived on pastries, canned spaghetti and meatballs, and beer (Scully et al., 1995).

In an Australian study, 73% of new admissions to a Care of the Elderly department were found to have low plasma vitamin C, with 30% in the range suggesting scurvy. Some improvements in memory, behavior, and cognitive performance have been reported with vitamin C supplementation in such populations (Richardson et al., 2002).

Purpura

Purpura, which simply means purple, is discoloration of the skin and mucous membranes resulting from intracutaneous and subcutaneous bleeding, which appears as petechiae or ecchymoses. Any type of large hemorrhage undergoes characteristic changes in color. As the red blood gives up its oxygen, it becomes deoxyhemoglobin, which is purple. In a few days, it is degraded to biliverdin (green) and bilirubin (orange).

Some diseases in which purpura is the most obvious physical finding include idiopathic thrombocytopenic purpura (ITP), thrombotic thrombocytopenic purpura (TTP), Henoch–Schönlein purpura, and purpura fulminans. (Note that "purpura" is the name of a condition, not a lesion; the plural "purpuras" refers to two or more diseases manifesting purpura, such as ITP, TTP, etc.)

Remember that here, as in other contexts, "idiopathic" means that the doctor does not know the cause, not that there is no cause. "ITP" could mean "immune thrombocytopenic purpura," as in a report of a small series of infants who received a recombinant hepatitis B vaccine (Ronchi et al., 1998), or children who received the measles–mumps–rubella vaccine, or children who had natural measles, rubella, or (rarely) mumps (Miller et al., 2001).

Purpuric lesions should be palpated. If such a lesion can be differentiated from normal adjacent skin by the fingertip with your eyes closed, the patient is said to have a palpable purpura. Such lesions are *never normal* and are said to imply an antigen–antibody complex (Fig. 7-6). However, palpable purpura, with no evidence of vasculitis on biopsy, has been described in association with hemarthrosis and hemothorax in a patient with scurvy. This patient, who had a history of schizophrenia, normally ate nothing except black beans and rice (Mowad et al., 1995).

In a febrile patient with purpuric macules, papules, or vesicles, consider bacteremia (meningococcemia, gonococcemia, staphylococcemia, and *Pseudomonas* infection), enterovirus infections (enterovirus cytopathic human orphan and Coxsackie), and rickettsial diseases (Fitzpatrick et al., 1979).

Petechiae and ecchymoses may result from well-intentioned folk remedies such as cupping, coining, and spooning, which are dermabrasion techniques intended to "draw out" illnesses. Such practices are used by Asians, Mexicans, and Eastern Europeans, among others (Stewart and Rosenberg, 1996b).

In the late 1990s, ecchymoses in children were routinely assumed, often incorrectly, to be a sign of child abuse and were reported to authorities. In their eagerness to comply with the law as well as to prevent more serious injuries to children, physicians may miss serious diseases and fail to consider innocent causes. Overzealousness may subject a child to the loss of a loving parent, as the parent incurs huge legal expenses and a devastating disruption to his personal and family life. Unwarranted reports will irreparably damage the patient–physician relationship and may even lead to malpractice liability (Kaplan, 1986). The physician cannot delegate his responsibility for making an accurate diagnosis to an agency of government.

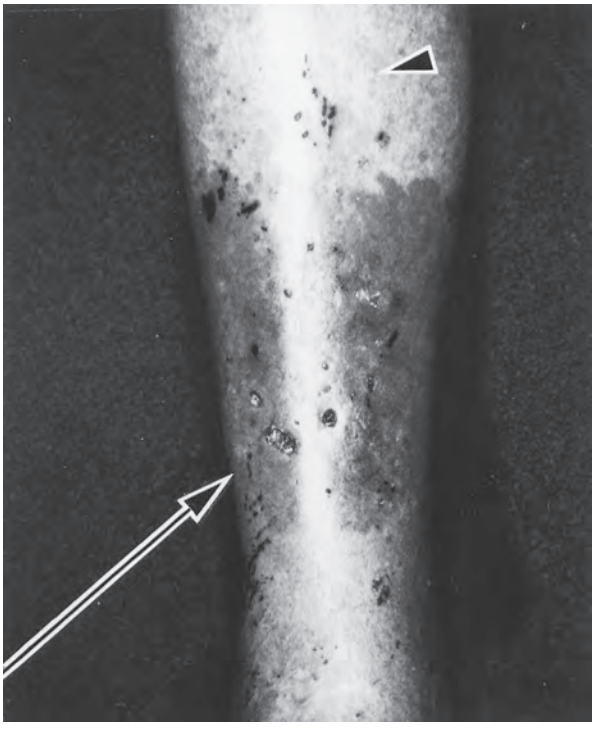


Figure 7-6 The arrowhead points to a collection of purpuric lesions high on the shin. The examiner could detect them with his eyes closed; hence, the patient has a palpable purpura. More distally, in a band of stasis pigmentation, the arrow points to some punched-out ulcers due to vasculitis. This patient had vasculitis due to cryoglobulinemia, the etiology of which I could never determine. Others called it "agnogenic," "essential," "cryptogenic," "idiopathic," or "mixed" cryoglobulinemia. Which of these modifiers is falsifiable? (The answer is in Appendix 7.4.)

An entity called *autoerythrocyte sensitization purpura* has been described, but every case that has been referred to me turned out to be factitious purpura, or a collection of self-administered love bites or pinches (see "Factitious Lesions and Delusions of Parasitism," as discussed later in this chapter).

Exanthems

Dimensions

An exanthem[1] is a temporary skin eruption or rash occurring as a symptom of a general disease, resulting from a direct invasion of the skin by an infectious agent, a toxin, or an immune response. A careful description of the rash in all its dimensions (including time course, morphology, and distribution) can lead directly to diagnosis and timely initiation of therapy (Cherry, 1982).

Repeated examination may be necessary to see rashes that are delayed or transient. The rash of Still disease is best seen during a fever, or it may be brought out by a hot bath. The same is said to be

[1] According to Gibbon, during the Dark Ages exanthemata were then "outflowerings" of raised embroidery upon silk, in the form of flowers done in silver or gold thread.

true of the rash of other febrile illnesses, such as rheumatic fever and Lyme disease. The macular erythematous rash of toxic shock syndrome may be confined to a small area, and it may change with blood pressure or blood flow to the skin (Smith and Jacobson, 1986).

The characteristic rash of *erythema chronicum migrans* was one of the clues to the infectious etiology of Lyme arthritis. The skin lesion begins as a red macule or papule that expands to form an enlarging ring with central clearing (Mast and Burrows, 1976; Steere et al., 1977). There is wide variability in the presentation of this rash. Multiple components of the clinical examination and epidemiologic context need to be factored in, and there are no criterion standards for testing the accuracy of what remains a clinical diagnosis (Tibbles and Edlow, 2007).

Urticaria

A very common type of skin eruption, affecting perhaps one fifth of the population at some time, is urticaria (Warin and Champion, 1974). An urticarial rash ("hives" or "nettles") consists of itchy red or white welts of varying size and shape, usually migratory and transient. Most often, urticaria will be part of the history rather than the physical examination. The physician needs to ask whether the patient ever had such an eruption after receiving penicillin or some other drug or after a potentially recurring exposure such as a bee sting (see Chapter 4). If the patient complains of recurring or chronic urticaria, the physician and the patient together will need to embark on historical detective work that is beyond the scope of this book. Causes of immune-mediated urticaria include inhalants, injectants, ingestants, infections, contactants, drugs, and cold (cold hives). There are also physical urticarias of which dermographism (*vide infra*) is one example.

Papulosquamous Eruptions

Elevated or palpable skin lesions accompanied by scale are called *papulosquamous*. They may occur with primary cutaneous disorders such as psoriasis, tinea, pityriasis rosea, lichen planus, or parapsoriasis; as a manifestation of a drug reaction; or as a sign of systemic disease such as lupus erythematosus, cutaneous T-cell lymphoma, secondary syphilis (Fig. 7-7), or Reiter disease. Tinea versicolor and pityriasis rosea may look very much alike; a KOH preparation makes the distinction (Fig. 7-8).

Vesicular, Bullous, and Pustular Eruptions

Vesicles are blisters containing clear fluid. Bullae are blisters larger than 0.5 cm in diameter. Pustules are blisters that contain purulent fluid.

Grouped vesicles on an erythematous base are characteristic of herpetic infections, both herpes zoster and herpes simplex. The former mostly involves skin in a dermatomal distribution, usually but not always unilateral (see Fig. 9-1). The latter may also involve mucous membranes and the mucocutaneous junction (see Chapters 13 and 22). Note that "herpes" comes from the Greek word for "wander."

Large, tense, clear bullae surrounded by erythema with histologic evidence of sweat gland necrosis were originally described in association with barbiturate-induced coma. These bullae are found over pressure points and areas likely to be traumatized. The lesions occur in approximately 6.5% of barbiturate-intoxicated patients. They have been noted in glutethimide coma, carbon monoxide poisoning, narcotic "overdose," methamphetamine abuse, 4% of cases of pure tricyclic overdose (Noble and Matthew, 1969), and hemiplegic stroke. Coma itself is apparently not a prerequisite, but neural damage of one sort or another appears to be the common factor (Sapira and Cherubin, 1975).

Figure 7-7 Papulosquamous eruption on the back, with lesions resembling those of pityriasis rosea, owing to secondary syphilis, which is generally suspected on the basis of skin and mucous membrane lesions. Syphilis is the "great imitator": Lesions may take many forms, also including macular, papular, follicular, or pustular. Lesions are generally symmetrical, dry, and nonpruritic. They are infectious; the diagnosis may be made by a positive dark-field examination for spirochetes. Also see Chapter 24. (Photograph courtesy of US Public Health Service. *Syphilis: A Synopsis.* Public Health Service Publication No. 1660, US Public Health Service, January 1968, with permission.)

Vesiculobullous lesions scattered on an erythematous base with significant golden crusting are caused by impetigo, a bacterial (staphylococcal and/or streptococcal) infection of the skin. But not all red lesions on a child's face are impetigo (Fig. 7-9).

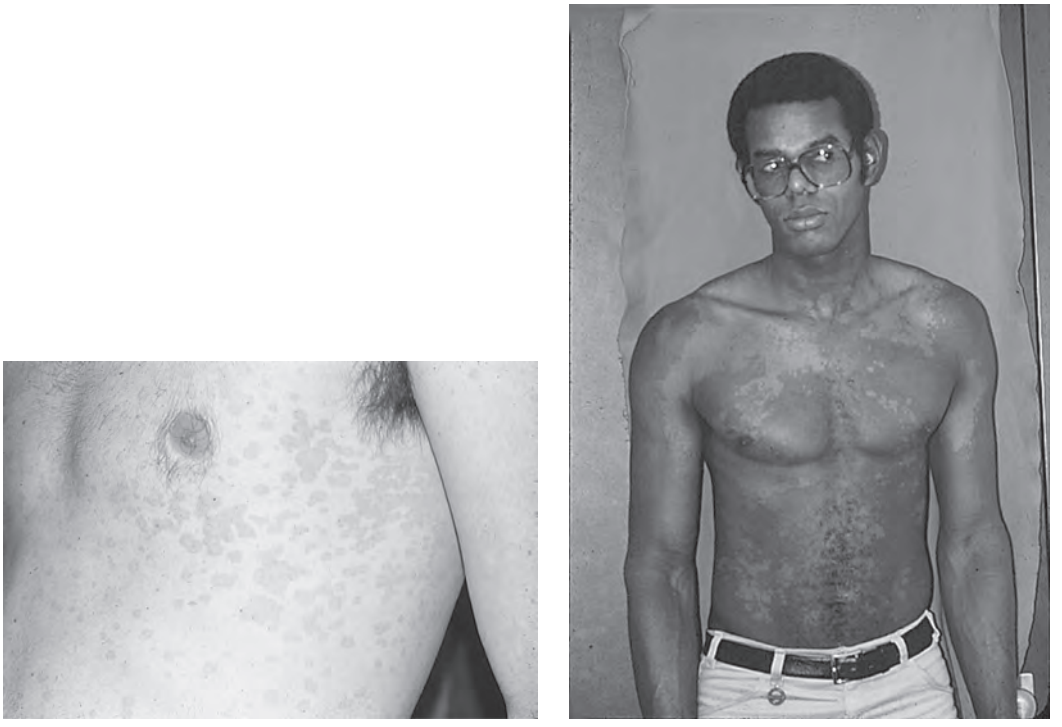
Other mucocutaneous conditions with vesicular or bullous lesions include (a) Stevens–Johnson syndrome, a severe form of erythema multiforme, often resulting from a drug reaction; (b) pemphigus, which comes from the Greek word for blister, discussed later in this chapter and in Chapter 13; (c) bullous pemphigoid; (d) dermatitis herpetiformis; (e) contact dermatitides such as that caused by poison ivy and other *Rhus* plants; (f) lupus erythematosus, occasionally; and (g) bacteremia. Lastly, septic emboli lead to isolated pustules on the extremities, surrounded by purpuric macules. Red papular pustules with white centers tend to be staphylococcal.

Skin lesions seen in gonococcemia and in the dermatitis–arthritis syndrome may be petechial, papular, vesicular, pustular, or bullous. They tend to be few (3 to 20) in number and are located on the distal extremities. The larger lesions may show a necrotic center, and the bullae may be hemorrhagic. The differential diagnosis includes *Neisseria meningitidis, Haemophilus influenzae*, and *Streptobacillus moniliformis* infections.

A papulovesicular eruption may be a cutaneous marker of mercury toxicity (Dantzig, 2003).

Smallpox (Variola)

Although smallpox was the first infectious disease to be declared extinct, the organism still exists in known locations for research



A B

Figure 7-8 **A:** The appearance of these lesions was suggestive of pityriasis rosea, but a KOH prep made the diagnosis of tinea versicolor. **B:** Tinea versicolor in a black patient. KOH prep was positive. (Photographs courtesy of Dr Chester Danehower, with permission.)

Figure 7-9 This young patient was treated by her pediatrician without success for suspected impetigo involving the nose. A KOH prep revealed the correct diagnosis of tinea faciei. (Photograph courtesy of Dr Chester Danehower, with permission.)

purposes and possibly in unknown locations as a biological weapon. Smallpox lesions progress from macules to papules to vesicles to pustules that develop umbilications and finally to scabs. In contrast with chickenpox (varicella), in which the lesions are pleiomorphic and in various stages of evolution, lesions of smallpox on one part of the body are generally in the same stage of development. The typical smallpox rash begins on the face, hands, then legs, and then spreads centrally to the trunk. Lesions are more abundant on the face and extremities and involve the palms and soles in a "centrifugal" distribution, unlike the chickenpox rash. The latter is "centripetal," largely affecting the trunk and thinning out towards the extremities.

In flat-type smallpox (2% to 5%), skin lesions are small and soft, accompanied by severe systemic toxicity, with 95% fatalities in unvaccinated patients (vs. 30% in typical smallpox). In hemorrhagic smallpox, the patient usually dies before the skin lesions develop (McClain, 1997).

The odor of smallpox is said to be quite distinctive.

Should a bioengineered form be used as a weapon, the presentation could be quite atypical.

Anthrax

Anthrax is endemic in many areas of the world, and 95% of cases are cutaneous. The lesion begins as a small papule that progresses over a day or two to a vesicle, which may be up to 1 to 2 cm in diameter, containing serosanguinous fluid. The vesicle ruptures, leaving a necrotic ulcer. There may be satellite lesions. A varying degree of edema, sometimes massive, may be present (Friedlander, 1997).

In the context of biological warfare, a much more lethal inhalational form is more likely. In the setting of possible exposure, a high index of suspicion is needed for patients presenting with an influenzalike illness. Patients will probably not have skin lesions.

Photosensitivity

Distribution is the key to the recognition of photosensitivity disorders. Both the involvement of sun-exposed areas and the noninvolvement of protected areas are important. (The part of the neck shaded by the chin, hair-covered areas, recessed parts of the orbits, and the upper lip just beneath the nose, are usually spared.) On the other hand, sun-exposed areas (e.g., the face and hands) can also be involved by contact dermatitis.

The earlobe sign may help identify a contact dermatitis due to a substance applied to the face with one hand. The contralateral

earlobe is involved because the index finger sweeps over it, and the ipsilateral earlobe is spared as the thumb hooks onto the mandible. In a man, bilateral earlobe involvement generally implicates the shaving cream, and unilateral involvement, the aftershave lotion (Rotstein and Rotstein, 1997).

Systemic lupus erythematosus and discoid lupus erythematosus (Fig. 7-10) have probably displaced pellagra as the most common etiologies of photosensitivity. Xeroderma pigmentosa and porphyria (other than acute intermittent porphyria) may also display this phenomenon. The pigmentation in argyria may be provoked by sun exposure and follow a photosensitive distribution.

Tetracyclines are by far the leading cause of drug-induced photosensitivity, followed by thiazides and the quinolone group of antibiotics. Other important photosensitizers are psoralens, retinoids, sulfonamides, sulfonylureas, amiodarone, naprosyn, nalidixic acid, and phenothiazines. Photosensitive drug eruptions may be either photocontact or systemic, with the latter producing a more generalized rash.

Polymorphous light eruption (Lim and Epstein, 1997), the most common of the idiopathic photodermatoses, affects up to 10% to 20% of the population in the US, England, and Ireland. It is often a diagnosis of exclusion. A classification of photosensitivity diseases is given in Table 7.3, and important dimensions of the history are listed in Table 7.4.

A rare photodermatitis, characterized by skin fragility and a vesicular eruption, resembles porphyria cutanea tarda but involves no abnormality of porphyrin metabolism. This has been associated with many drugs but is especially characteristic in children with juvenile rheumatoid arthritis who receive naprosyn, up to 6% of whom may be affected. Skin fragility may continue for months after the drug is stopped (Creemers et al., 1995; Girschick et al., 1995).

Phytophotodermatitis can be quite severe, mimicking a partial thickness burn. "Nonaccidental trauma" (child abuse) was suspected in a toddler with a red and blistered area on her buttocks until her mother made the diagnosis: She brought in a specimen of the herb rue (*Ruta graveolens*), which was growing by the paddling pool where the child had been playing unclothed, and a magazine article on the poisonous nature of certain plants (Hill and Pickford, 1997).

Potentially sensitizing plants, to which gardeners and agricultural workers may be exposed, include celery, parsnip, and parsley.

Figure 7-10 Classic lesion of discoid lupus erythematosus. Follicular plugging is frequently seen in association with these lesions. (Photograph courtesy of Dr Chester Danehower, with permission.)

TABLE **7.3** *Classification of photodermatoses*

A. *Unknown cause*
- Polymorphous light eruption
- Actinic prurigo
- Hydroa vacciniforme
- Chronic actinic dermatitis
- Solar actinic dermatitis

B. *Secondary to exogenous agents*
- Phototoxicity (systemic and contact)
- Photoallergy (systemic and contact)

C. *Secondary to endogenous agents (porphyrias)*

D. *Photoexacerbated dermatoses*
- Autoimmune diseases
- Lupus erythematosus
- Dermatomyositis
- Pemphigus
- Bullous pemphigoid
- Genodermatoses (e.g., xeroderma pigmentosum)
- Infectious disease (herpes simplex labialis)
- Nutritional deficiency
- Pellagra
- Pyridoxine deficiency
- Primary dermatologic diseases (e.g., psoriasis, lichen planus actinicus, acne rosacea)

When looking for a cause of contact dermatitis or photodermatitis, be sure to ask about medicaments applied by the patient's consort. A patient developed erythematous vesicular lesions on thighs, buttocks, and left shoulder upon receiving ultraviolet A radiation in a suntan cubicle; her husband had been applying a topical ketoprofen preparation (Mirande-Romero et al., 1997).

TABLE **7.4** *Dimensions of the history in a patient with possible photosensitivity*

- Exacerbation by sunlight and/or artificial light whether through window glass or through UVB or broad-spectrum sunscreen
- Time of onset postexposure and duration
- Amount of exposure required to produce eruption
- Distribution (all sun-exposed skin or specific sites?)
- Age at onset
- Previous sun sensitivity
- Other conditions (e.g., connective tissue diseases)
- Occupation
- Exposure to systemic and topical photosensitizing agents (drugs, foods, soaps, cosmetics, plants, sunscreens, etc.)
- Diet (evidence of malnutrition?)
- Family history; ethnic background

From Lim HW, Epstein J. Periodic synopsis: Photosensitivity diseases. *J Am Acad Dermatol.* 1997;36:84–90, with permission.

An agent that has been used for years can still cause an allergic contact dermatitis. The patient changes, even if the agent does not.

Tinea Infections

If a lesion is red, pink, scaly, or any combination of these, Dr Chester Danehower of Peoria, Illinois, suggests doing a KOH preparation, even if the diagnosis of a contact dermatitis seems obvious, as because of its location under a watch (Fig. 7-11). The lesion often turns out to be fungal in origin.

If fungus is found in any location, it will probably be found elsewhere too. Tinea pedis, for example, will often be associated with tinea cruris, tinea capitis, and/or tinea corpora (Fig. 7-12).

Skin Cancers

Malignant Melanoma

Malignant melanomas are said to be differentiable from other lesions by examining them for red color (a sign of immunologic reactivity against a "foreign" substance), white color (amelanotic sites indicating depigmentation due to tumor regression), or blue color (said to be peculiar to some melanomas but also occurring in the benign blue nevus). Whatever the correct pathophysiologic explanations for these colors, the clinical significance is correct; they are flags for a possible malignancy. The mnemonic might be the colors of the flags of the US, the UK, New Zealand, or Australia. Nevertheless, malignant melanoma can be in varying shades of brown. Also, if you see black or thundercloud gray, you must think melanoma.

Malignant pigmented tumors tend to be asymmetric and to have a notch.

Malignant melanomas are usually larger than a pencil eraser when first diagnosed. It is obviously desirable, however, to diagnose them sooner.

The ABCD rule for diagnosing a possible melanoma is *A* for asymmetry, *B* for irregular border, *C* for variation in color, and *D* for diameter greater than 6 mm. Dr Danehower suggests not waiting for the *D*; he has diagnosed many melanomas less than 6 mm in size.

Figure 7-11 Students invariably diagnose this erythematous and scaling lesion, present under the patient's watch, as an allergic contact dermatitis probably secondary to nickel. A simple KOH prep, however, established the correct diagnosis of tinea corporis. On further examination, the patient was found to have rather generalized tinea corporis and tinea versicolor. (Photograph courtesy of Dr Chester Danehower, with permission.)

Stretching a suspicious nevus between two fingers, especially after coating it with a few drops of soap or oil, may make erythema and irregular pigmentation more obvious. It is also important to use adequate lighting, such as direct sunlight or a strong incandescent or quartz halogen light. Fluorescent light hinders diagnostic accuracy because its discontinuous spectrum turns the pink hues of dysplastic nevi to a dull gray (Crutcher and Cohen, 1990).

The incidence of malignant melanoma has a complicated relationship with exposure to sunlight (*vide infra*), but these cancers can occur on any part of the skin or mucous membranes. The plantar surface is a common site in nonwhite persons (Rogers and Gibson, 1997).

Try to determine the malignancy of the various lesions shown in Fig. 7-13. Do not read the legend until you have written down your answers.

Benign dysplastic nevi, which may reveal shades of brown, are probably not premalignant themselves but are markers for patients who may develop melanoma. Patients with dysplastic nevi are said to have at least a 6% lifetime risk of melanoma (Crutcher and Cohen, 1990).

The rare but completely benign dermatofibroma may be distinguished from malignant melanoma by means of the dimple sign. The dermatofibroma will indent (dimple) if you squeeze it from the sides; the melanoma will not. Alas, this sign cannot be used to distinguish the other lesions from melanoma, and so we are left with the red-white-blue-notch asymmetry (ABCD) system.

A rule suggested by Dr Tamzin Rosenwasser is to biopsy or excise a mole if it looks much different from all the others.

Squamous Cell and Basal Cell Carcinomas

Squamous cell carcinomas are also dangerous. Location in an area caudad to lines running from the angles of the mouth to the earlobes suggests this diagnosis.

Above that line, nonpigmented skin cancers are more likely to be basal cell carcinomas, which are less malignant in that they do not tend to metastasize, although they are locally invasive with potentially devastating consequences called a "rodent ulcer" (see Figs. 7-14 and 10-2). These cancers tend to have a "pearly" border—that is, a light-colored area somewhere on the edge of the tumor with the color and reflectance of pearl. These findings, coupled with any vessel or telangiectasia apparent anywhere on the lesion, strongly suggest that it is a basal cell carcinoma. But shiny intradermal nevi with associated telangiectasis, easily confused with basal cell carcinoma, may occur on the faces of young persons, especially redheads (J. Scherzer, *personal communication*, 1998).

Skin Cancer and Ultraviolet Exposure

Nonmelanoma skin cancer generally occurs in fair-complexioned individuals in the exposed areas of skin after extended periods of exposure over a lifetime, usually after the age of 60. Melanoma generally occurs in individuals who have a history of intermittent severe blistering sunburns in both childhood and adult life. Although the incidence increases with age, a substantial number of melanomas occur in patients under the age of 50.

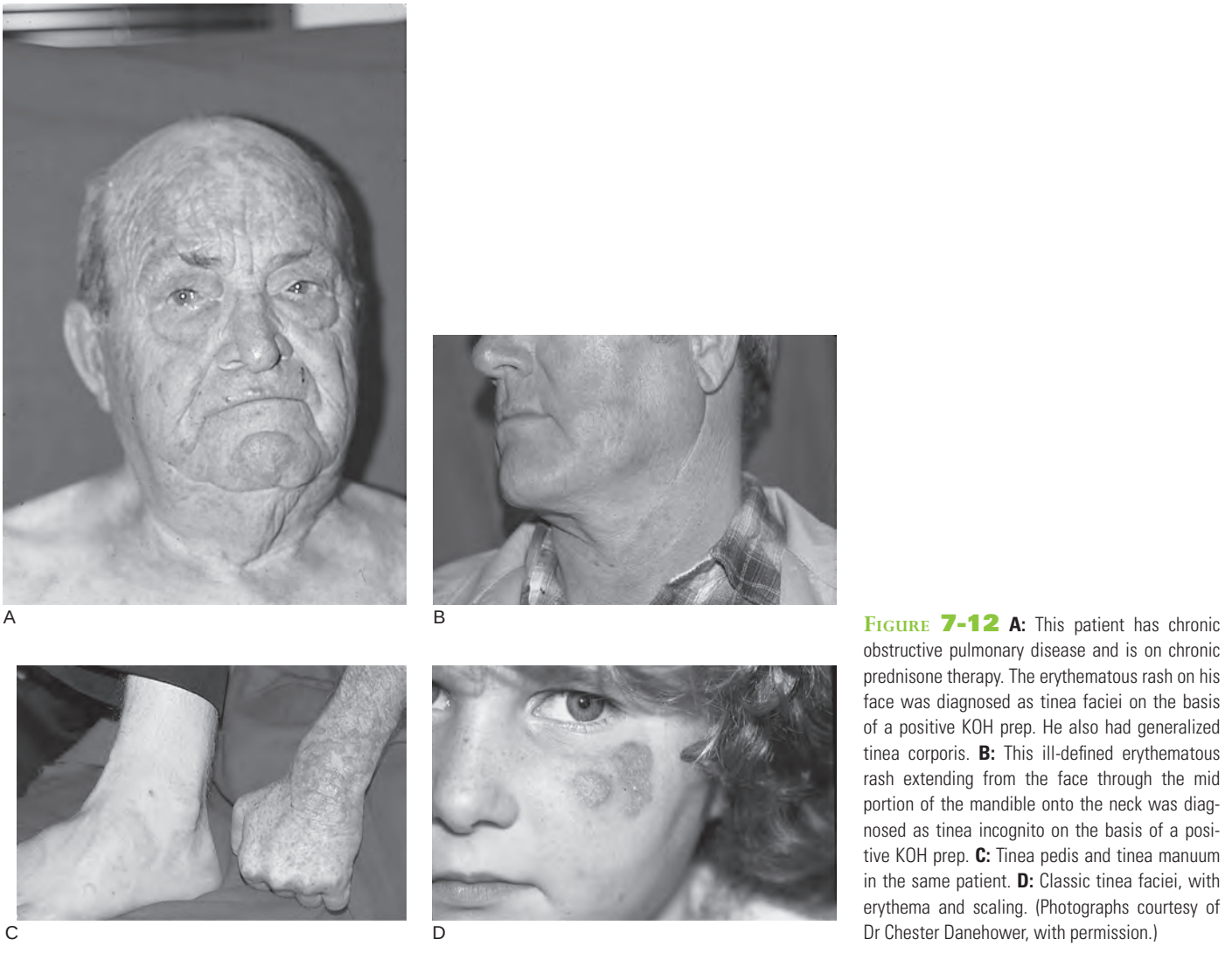


Figure 7-12 **A:** This patient has chronic obstructive pulmonary disease and is on chronic prednisone therapy. The erythematous rash on his face was diagnosed as tinea faciei on the basis of a positive KOH prep. He also had generalized tinea corporis. **B:** This ill-defined erythematous rash extending from the face through the mid portion of the mandible onto the neck was diagnosed as tinea incognito on the basis of a positive KOH prep. **C:** Tinea pedis and tinea manuum in the same patient. **D:** Classic tinea faciei, with erythema and scaling. (Photographs courtesy of Dr Chester Danehower, with permission.)

Because sunburn is chiefly caused by ultraviolet B (UVB, wavelength from 290 to 320 nm), it is suggested that the regular use of sunscreens that block this wavelength might protect against the development of both melanoma and nonmelanoma skin cancer. However, most sunscreens offer limited protection against ultraviolet A (UVA, wavelength 320 to 400 nm). Atmospheric ozone also offers little protection against UVA. Even the thinnest layer of window glass screens out 100% of UVB but has no effect on UVA. UVA may well serve as a promoter of the carcinogenicity of UVB or may also be carcinogenic itself. Patients who have received UVB therapy for skin conditions over an extended period have not shown an increased incidence of skin cancer, while patients who have received extended UVA therapy have developed both melanoma and nonmelanoma skin cancer with increased incidence (D. Printz, *personal communication*, 1998).

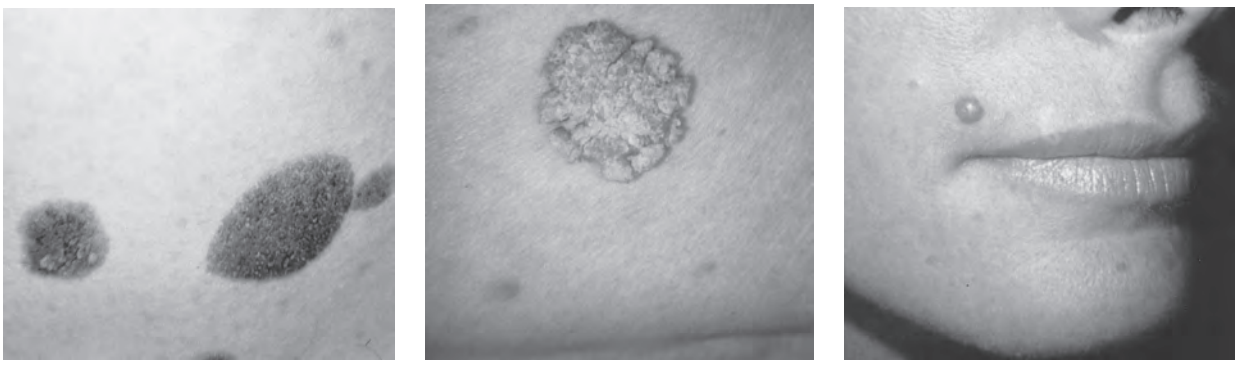
Kaposi Sarcoma

This lesion usually consists of purple masses, which are sometimes scaly. Formerly a rare, slow-growing malignancy confined mostly to the lower extremities of older men, usually of Mediterranean stock, the disease is now commonly seen in association with AIDS. The new form of the disease tends to affect younger persons, to be faster growing, and to become more widely disseminated (Fig. 7-15). It also involves mucous membranes (see Chapters 10 and 13).

Metastatic Tumors

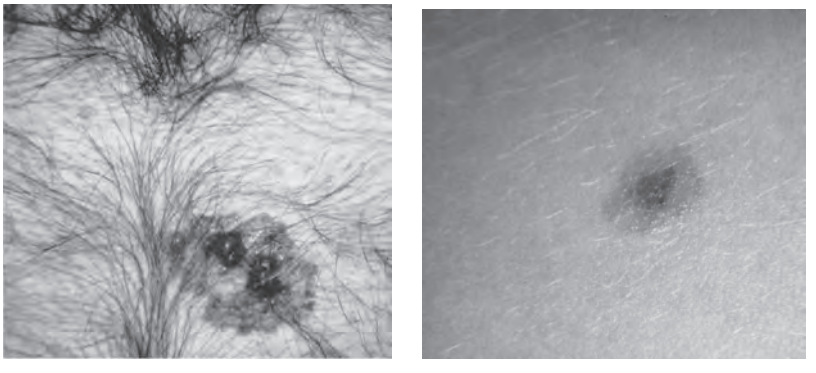
Tumors may metastasize to the skin. The most common are colon, ovary (in women), oat cell (in men), melanoma, and breast, supposedly in that order, forming the acronym COMB. The word "comb" reminds us of the scalp, where the differential diagnosis does not hold, with the most common metastasis to the scalp being renal cell carcinoma.

About one fifth of B-cell lymphocyte tumors will migrate to the skin at some time in the course of the disease, although T-cell tumors are better known for this behavior. Of the latter, mycosis fungoides (Fig. 7-16) is the best known and most pleiomorphic. Sézary syndrome has a characteristic cell, the Sézary cell, which is identifiable in the peripheral blood as well as the skin. Inflammation from Sézary syndrome may produce the "red man," a white person who looks as if he has just received a large dose of histamine—another cause of the red man syndrome discussed under "Erythema."



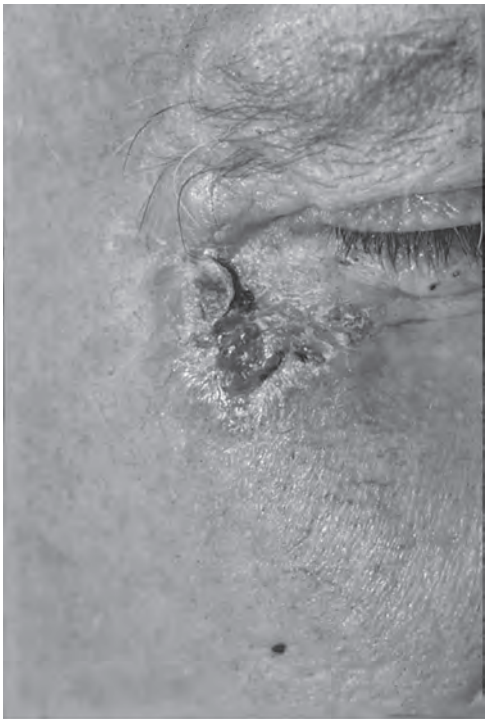
A B C

D E F

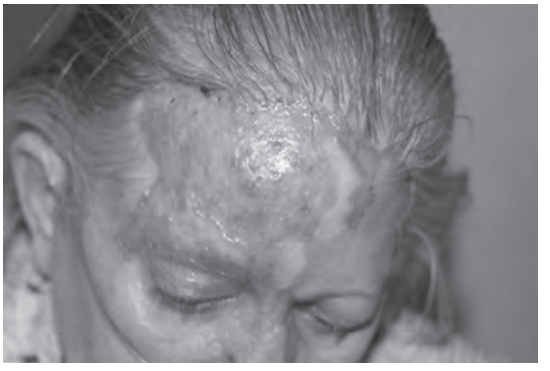


G H

Figure 7-13 **A:** Seborrheic keratoses, also called *senile warts*. Such lesions have no red spots, white spots, or notching, and they occur after middle age. They are symmetrical. **B:** Another seborrheic keratosis, with a more "warty" appearance. **C:** Intradermal nevus, the common adult mole, diameter 5 mm. This type of nevus should be smaller than 6 mm in diameter. **D:** Intradermal nevus with hairs, a statistical sign of benignity. **E:** Malignant melanoma, 3 × 2 cm in diameter, showing marked regression producing noteworthy asymmetry, and with variations in color. **F:** Lentigo maligna (Hutchinson's melanotic freckle, diameter 1.1 cm) in an 85-year-old patient. Note the irregular borders, asymmetry, and color variations, ranging from tan to brown to black. This is *in situ* melanoma. Such lesions usually begin as a brown macule on the face in middle-aged persons. **G:** Malignant melanoma, diameter 2.5 cm, demonstrating notched borders and variations in height, asymmetry, and color. **H:** Compound (congenital) nevus, diameter 7 mm. There is some variation in color, but no black or amelanotic spots; the lesion is symmetrical and has regular borders. (Photographs courtesy of Dr Joseph Scherzer of Scottsdale, Arizona, with permission.) **Management:** Using the rule of "red, white, blue, or notch," the rule of "when in doubt, cut it out," and the rule of the hairs, you would ignore A, B, C, D, and H but would have to excise E, F, and G. However, Dr Claud Boyd of Augusta, Georgia, notes that in today's litigious climate, it is wise to add the rule: "If the patient asks about it, biopsy." In fact, occasionally the patient is right and the dermatologist is wrong,



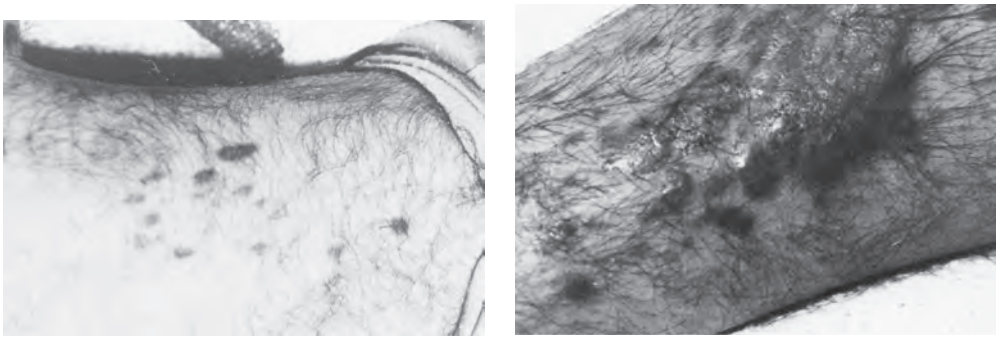
A



B

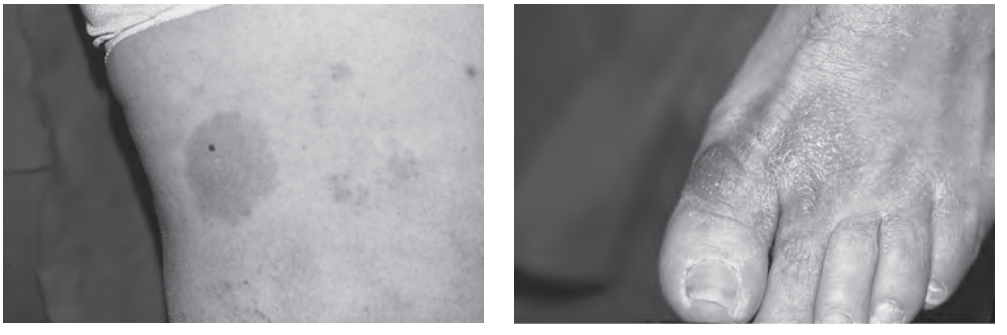
C

FIGURE 7-14 **A:** Classic basal cell carcinoma involving the lateral canthal area. Note rolled-up border and ulceration. **B:** Extensive basal cell carcinoma in an elderly patient. **C:** Pearly lesion with telangiectasia, typical in basal cell carcinomas. (Photographs courtesy of Dr Chester Danehower, with permission.)



A B

Figure 7-15 **A:** Kaposi sarcoma on the arm of a young AIDS patient. **B:** An older lesion on the thigh of the same patient. At first, this lesion was similar to the one shown in **(A)**.



A B

Figure 7-16 **A:** The plaque on the left is mycosis fungoides. The nonspecific lesion on the right was KOH positive and represents tinea corporis. A patient may have more than one diagnosis! **B:** The tumor is mycosis fungoides, which arose in a plaque. (Photographs courtesy of Dr Chester Danehower, with permission.)

Lesions Resembling Carcinoma

The annular lesion of blastomycosis may mimic carcinoma when it appears on the face. Other organisms, including histoplasmosis, coccidioidomycosis, and *Mycobacterium marinum* (*M. balnei*), may also produce indolent, epithelialized lesions.

Excrescences: Keratoses

A keratosis is a hyperkeratotic papule, varying from yellow or flesh-colored to quite dark, even black in the case of the seborrheic keratosis (Fig. 7-13A). Seborrheic or senile keratoses are a common but benign occurrence in old age. The lesions are of variable color and have a greasy, stuck-on appearance. In fact, they may be easily removed with a sharp curette because they involve only the superficial layer of the skin.

Palmar keratoses are discussed in Chapter 24.

Actinic (solar) keratosis is a buildup of keratinous skin, which preserves some of the major skin creases, often found on the face or dorsal aspects of the hands of sailors, outdoor stoop laborers, and others with chronic sun exposure.

The posterior aspect of the neck of outdoor workers exhibits solar elastosis (actinic "weathering") called *cutis rhomboidalis nuchae*, which is characterized by waxy-looking, leathery skin evidencing deep wrinkles. This has been stated (incorrectly) to be the origin of the term *redneck*.[2] Lesions resembling seborrheic keratoses that suddenly appear and/or expand, often with pruritus, comprise the sign of Leser and Trelat (Fig. 7-17), which is of serious significance. (Note that multiple seborrheic keratoses per se do not comprise this sign.) Originally described by two European surgeons in the nineteenth century, the world's literature long consisted of only ten cases. However, for some reason, the sign has been increasingly recognized in the past decade as one of the dermatologic signals of internal malignancy. Most common are abdominal carcinomas, usually gastric adenocarcinoma, but any type of neoplasm can be involved, including leukemia or lymphoma (Greer et al., 1978; Kaplan and Jegasothy, 1984; Lynch et al., 1982; Safai et al., 1978; Schwartz, 1981). This association with occult malignancy is reminiscent of acanthosis nigricans (see later in this chapter) with which the sign of Leser and Trelat has coexisted.

Neurofibromas

These fleshy, pedunculated tumors (see Fig. 10-1) permit the diagnosis of neurofibromatosis (von Recklinghausen disease). Before

[2] *Redneck* first appeared in Mississippi during the rise of a populist politician whose supporters, most of whom were poor rural whites, wore red bandannas around their necks (Rogers, 1986).

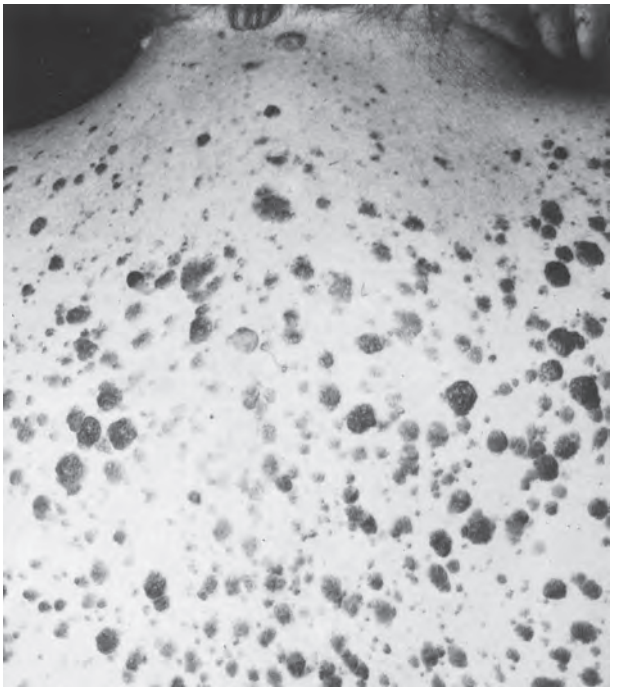


Figure 7-17 The sign of Leser and Trelat. Note that multiple seborrheic keratoses per se do not have the same significance as this sign. (Photograph courtesy of Dr Cliff Dasco of California, with permission.)

the actual appearance of the tumors, the diagnosis is suggested by the finding of at least six café au lait ("coffee with milk") spots at least 1.5 cm in diameter. In a group of 6,856 normal adults, only 10% had café au lait spots and never more than five, while 75% of 223 individuals with proven neurofibromatosis had six or more spots greater than 1.5 cm in diameter (Crowe, 1964). If you see café au lait spots, search the iris for Lisch nodules.

Self-test. Calculate the sensitivity and specificity of the sign of "six or more café au lait spots at least 1.5 cm in diameter" for neurofibromatosis. For a patient from a population with a 1 in 3,500 prevalence of disease (the general population), what is the predictive value of a positive test? A negative test? For a patient whose father has neurofibromatosis, what is the predictive value of a positive test? A negative test? (The trait is inherited as an autosomal dominant.) Answers are in Appendix 7.3.

Some say that axillary freckles are also diagnostic. They were found to be present in 22% of neurofibromatosis patients, all of whom had other evidence of hyperpigmentation such as café au lait spots or diffuse duskiness (Crowe, 1964). However, I have seen such freckles in the absence of any other sign of neurofibromatosis. One might say, "All that it proves is that the patient does not have the rest of the syndrome … yet."The epistemologic problem is that "yet" can be stretched, if not to infinity, at least past the lifetime of the physician or patient. (This relates to the general problem of statements that are not falsifiable. See the discussion regarding Raynaud phenomenon versus Raynaud disease in Chapter 18.)

Tuberous Sclerosis

Small groups of fleshy tumors, seeming at first glance to be acne, may be found in the nasal creases of patients with tuberous sclerosis, also known as *epiloia* or *Bourneville disease*. The paranasal tumors are called *adenoma sebaceum* and are actually hamartomas. Hamartomas also afflict the heart, kidneys, and brain, with the last being responsible for the seizures with which these patients often present.

Other skin signs of tuberous sclerosis include a depigmented area in the shape of an ash leaf (best seen under a Wood's light), periungual fibromas like those seen in Sipple syndrome, shagreen (shark skin) patches, and café au lait spots (like those in neurofibromatosis) with borders said to resemble the smooth coast of California, in contrast to the café au lait spots in Albright polyostotic fibrous dysplasia, which are likened to the rugged coast of Maine. Of these, the ash leaf is the earliest sign to appear (O'Brien, 1973), if it appears.

Skin Tags (Acrochordons)

Acrochordons are simple papillomatous lesions, usually at least 2 mm in height, often pedunculated, most easily found on the upper trunk, in or near the axilla or neck, but also seen on the head near the skin folds of the eyes and on the lower half of the body.

An Exercise

In patients referred (for other reasons) for colonoscopy, these skin tags are about 75% sensitive and about 75% specific in predicting the demonstration of colonic polyps (Chobanian et al., 1985; Leavitt et al., 1983). Can colonic polyps—a precursor of colonic carcinoma—be predicted simply from the presence of acrochordons?

To answer this question, we also need to know that the prevalence of colonic polyps in asymptomatic persons over the age of 50 is 5%.

Make a 2 × 2 table (see Chapter 1), and comment on the usefulness of this sign (see Appendix 7.5).

Insulin Resistance

Skin tags are now considered a sign of insulin resistance (Garcia Hidalgo, 2002) and thus of type 2 diabetes and other features of the metabolic syndrome (also called *syndrome X*) (Cordain et al., 2003). This syndrome is associated with a number of risk factors for cardiovascular disease, including hypertension, type 2 diabetes, dyslipidemia, obesity, and hyperuricemia.

Keratoderma Blennorrhagica

This lesion (Fig. 7-18) is considered to be pathognomonic of Reiter syndrome. The example shown is the fully developed form, which resembles the top of a carrot with the greens cut off. Notice especially the one on the patient's left knee and the two near the calcaneus. If an astute observer had not remembered to examine the soles of the feet, this patient's urethritis and arthritis might have gone undiagnosed. The lesion is often associated with circinate balanitis (see Chapter 21).

Atypical cases may be misdiagnosed as pustular psoriasis, even by experts.

Xanthomas

Xanthomas are collections of cholesterol and other fats. They have a shiny surface and a consistency like rheumatoid nodules and syphilitic gummas—firm but not hard. Some are located on the extensor surfaces, while others are located over pressure points

A B

FIGURE 7-18 Keratoderma blennorrhagica.

such as the elbow, knee, heel, and ischial tuberosities (Fleischmajer and Schragger, 1971; Polano et al., 1969).

With the possible exception of xanthelasma (*vide infra*), xanthomas are never normal, although some types are not diagnostic of a particular type of hyperlipidemia.

Even if the lipids are normal, the patient might have either (a) local tissue abnormalities; (b) an associated systemic disorder, especially a lymphoproliferative disease; or (c) altered lipoprotein structure or function (Parker, 1986).

There are several types of xanthomas (Table 7.5). *Xanthelasma* are fatty, yellowish deposits beginning in the periocular skin folds. They occur in 25% of patients with type III hyperlipoproteinemia but are also common in types II and IV. Because the latter are so much more prevalent than type III hyperlipoproteinemia, most of the time xanthelasma signify the presence of type II or IV. Some apparently normal individuals may also have xanthelasma, but these persons may actually have apoprotein abnormalities (Douste-Blazy et al., 1982).

TABLE **7.5** *Types of xanthomas*

Lesion	Type of hyperlipoproteinemia
Xanthelasma	II, III, IV, and supposed normals
Xanthomas	
Tuberous	Any type
Eruptive	Any type
Finger-fold	II or III
Palmar	III, rarely IV, or paraproteinemia
Tendon	II or III

From Fleischmajer R, Schragger AM. Familial hyperlipoproteinemias. *Modern Med.* 1971;April 15:97–104; Parker F. Normocholesterolemic xanthomatosis. *Arch Dermatol.* 1986;122:1253–1257; and Polano MK, Baes H, Hulsman AM, et al. Xanthomata in primary hyperlipoproteinemia. *Arch Dermatol.* 1969;100:387–400, with permission.

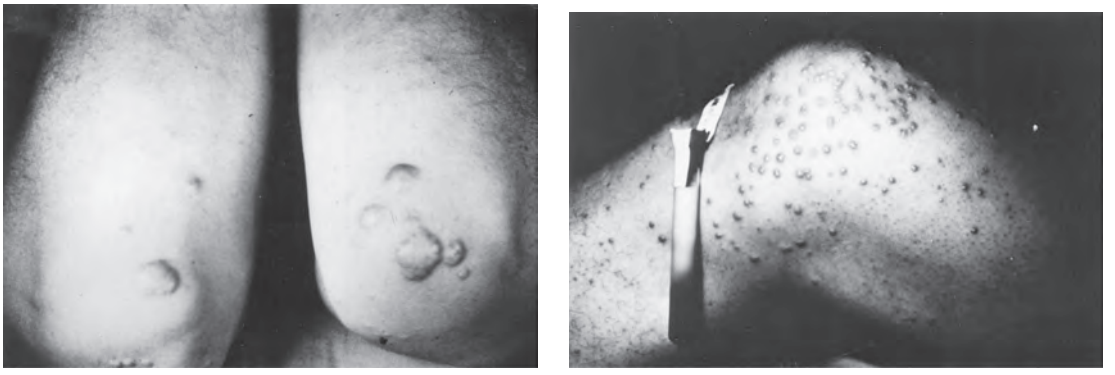
Tuberous xanthomas are shaped like tubers or potatoes (Fig. 7-19A). The individual tubers tend to be grouped together and may appear and disappear over periods of weeks, depending on the state of the patient's blood lipids. These lesions always signify a hyperlipoproteinemia. A look at the serum may help distinguish the type. If the serum is clear, the patient has hypercholesterolemia rather than high triglycerides and thus probably has hyperlipoproteinemia type II (Parker, 1986). See also Chapter 28.

Eruptive xanthomas look like an eruption, that is, they are characterized by their inflammatory component and are too small to resemble tubers. Those eruptive xanthomas secondary to the hyperlipemia of diabetes are given a special name, *xanthoma diabeticorum*. Patients with eruptive xanthomas will have turbid serum from the excess triglycerides.

If the xanthomas have the shape of tubers but also occur in crops like an inflammatory eruption, they may be called *tuberoeruptive* (Fig. 7-19B). Xanthomas can also be flat (therefore nontuberous) and bland (therefore noneruptive) in which case they are named by their location: finger-fold, palmar, tendon, and so forth. Finger-fold xanthomas are seen in type III hyperlipoproteinemias and very rarely in type II. *Palmar xanthomas* are little fatty beads that appear in the palmar creases. These are seen in only half the patients with type III but rarely in type IV or in the paraprotein hyperlipoproteinemias (Parker, 1986). They have also been seen in a child with hyperlipidemia due to biliary cirrhosis. *Tendon xanthomas* are the hallmark of type II hyperlipoproteinemia. Rarely, they may also be seen in type III. Christian's dictum applies. (Colloquially translated: When you hear hoofbeats, do not look for zebras.) If you see tendon xanthomas, diagnose type II over type III.

One can go no farther with the physical examination in these conditions. The xanthomatous patient deserves a laboratory examination (see Chapter 28).

Another cause of yellow subcutaneous papules or plaques is *pseudoxanthoma elasticum*. Patients with this hereditary disorder of elastic tissue often have severe premature vascular disease. Carriers of the gene, representing up to 1% of the general population, may



A B

Figure 7-19 **A:** Tuberous xanthomas. **B:** Tuboeruptive xanthomas in a diabetic with secondary hyperlipemia. (From *Consultant Magazine,* Cliggott Publishing Group of CMP Healthcare Media, Darien, CT, with permission.)

also be prone to cardiovascular disease (Schwartz, 1979). A skin biopsy showing calcification and fragmentation of elastic fibers has diagnosed this condition 25 years after the onset of severe coronary disease and cerebral infarction in a patient who did not have visible skin findings (Araki et al., 2001).

For the Attending. What Christian actually said was this: "Uncommon manifestations of common diseases are more common than common manifestations of uncommon diseases." This is intuitively appealing but not necessarily true. Rigorously stated, it means that $(a \times c) > (b \times d)$, where

a is the prevalence of the common disease A

b is the prevalence of the uncommon disease B

c is the frequency of the uncommon manifestation of A

d is the frequency of the common manifestation of B.

This is obviously not true for all possible values of *a, b, c*, and *d*. Also, remember that there are places where zebras are more common than horses.

Cherry Angiomas

These small (about 1 mm) raised red lesions, also called *De Morgan spots*, differ from papules in having a perfectly discrete border with surrounding normal skin. They are usually found on the chest and upper abdomen and are perfectly benign. Unlike a red melanoma, they have a perfectly symmetrical and smooth dome.

At one time it was thought that cherry angiomas were a sign of visceral carcinomatosis. This was due to a statistical artifact: The cherry (formerly called *senile*) angiomas appeared in middle-aged subjects at the time they were entering the high-risk decades for visceral carcinomas.

Acanthosis Nigricans

Acanthosis nigricans is a black or dirty brown, hyperkeratotic, velvety plaque appearing in the axillae and other intertriginous areas. It may be seen as a harbinger of occult malignancy, in which case it may have a rapid onset and spread. Much more commonly, acanthosis nigricans occurs in association with benign conditions and may be seen in as many as 74% of unselected obese patients. Acanthosis nigricans reportedly occurs in 5% of the population (Stone et al., 1995). Rarely, it is familial.

The history of this abnormality gives an interesting perspective on the progress of knowledge about clinical examination. In 1959, an evening with the *Quarterly Index* revealed only a few papers on acanthosis nigricans as a sign of internal malignancy, most by a New York private dermatologist named Curth. After several decades of searching among my own patients, I still had not used the information. Then there was an explosion of interest in this sign in metabolic abnormalities. A 5-minute computer search of the literature from 1984 to 1986 produced several feet of citations. In addition to the association with at least three different types of insulin resistance (both alone and together with hypothyroidism, obesity, systemic lupus erythematosus, polycystic kidneys, or acral hypertrophy), acanthosis nigricans had been described in Lawrence–Seip syndrome (generalized lipodystrophy), cutaneous insulin reaction, nonneoplastic masculinization of women, and Crouzon disease (both alone and in further association with periapical cemental dysplasia). It was described in connection with various drugs such as systemic corticosteroids, nicotinic acid, or oral contraceptives. The original association with malignancy had now become so unusual that there were only isolated case reports of acanthosis nigricans with mycosis fungoides, adenocarcinoma of the stomach or gallbladder, and adrenal carcinoma. Many of the reported associations could be purely coincidental, given that the condition is much more common than originally recognized.

A MedLine search turned up 200 articles on acanthosis nigricans between 1996 and early 2004, 82 of which also concerned insulin resistance, probably the underlying cause of many of the other associations. Control of the hyperinsulinism leads to improvement in the acanthosis nigricans (Garcia Hidalgo, 2002)—in one patient even before his coexisting hypothyroidism was corrected (Kuroki et al., 1999).

Supernumerary Nipples

Supernumerary nipples are sometimes confused with other skin lesions, such as nevi (see Chapter 15.)

Umbilicated Papules

The most common condition causing umbilicated papules is molluscum contagiosum. The causative virus may be sexually transmitted or spread by autoinoculation. The lesions generally occur on the face, the trunk, or the anogenital region.

Degos syndrome, malignant atrophic papulosis, is a progressive vascular occlusive disorder that afflicts almost any organ of relatively young men but especially the intestine. The skin lesion is conveniently displayed on the abdomen, usually in crops. Each central umbilicus is porcelain white and surrounded by an erythematous halo (Strole et al., 1967).

Scars

Signs of Drug Abuse

Scars are extremely useful signs of drug abuse, as shown in Figs. 7-20–7-26. A more encyclopedic treatment is found in *Drug Abuse: A Guide for the Clinician* (Sapira and Cherubin, 1975).

Other Scars

In whites, postsurgical scars show inflammation for up to 2 years. They then blend with the normal skin for about 8 years. Only after 10 years do they begin to develop pigmentation. Black skin has a tendency to heal any lesion with either hyper- or hypopigmentation.

Exuberant collagenosis in a scar, more commonly seen in blacks, is called *keloid formation*.

Sarcoid may appear in scars as localized irregularities, like microkeloids.

Tissue-paper scars are seen in porphyria, Ehlers–Danlos syndrome, and homocystinuria (Carey et al., 1968).

Excoriations

Signs of excoriation can be correlated with a history of itching (see Chapter 3). Excoriations should prompt a careful search for other signs of skin disease. Lichenification is often a clue to chronic excoriation; the patient always complains of itching and may often scratch during the course of the examination. In the absence of visible skin disease, one should consider internal diseases. The most common etiologies are the secondary hyperparathyroidism of uremia, polycythemia rubra vera, lymphoma (especially Hodgkin disease), and obstructive liver disease. Lastly, itching due to the retention of bile salts may precede the appearance of jaundice.

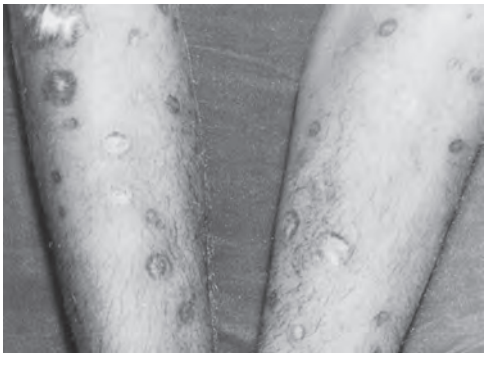


Figure 7-20 Skin popping. This patient developed all these sharply demarcated, punched-out, hypopigmented scars from the subcutaneous injection of a single batch of contaminated heroin. They were not due to an allergic reaction, as shown by subsequent challenge with subcutaneous injections of pure morphine, which was tolerated without sequelae. (From Sapira JD. The narcotic addict as a medical patient. *Am J Med.* 1968;45(4):555–588, with permission.)

Figure 7-21 This drug user's antecubital fossa shows two postabscess scars with characteristic, poorly demarcated borders and two short segments of "railroad tracks" (not "tracts"). (From Sapira JD. The narcotic addict as a medical patient. *Am J Med.* 1968;45(4):555–588, with permission.)

Figure 7-22 Here is an extremely broad venous "railroad track" seen on the extensor surface of the upper extremity. The antecubital fossae were clear in this case because the patient had no veins there. All accessible veins were, or had been, under this scar. (From Sapira JD. The narcotic addict as a medical patient. *Am J Med.* 1968;45(4):555–588, with permission.)

Ulcers and Open Sores

Ulcers arise from external trauma (e.g., scratching), from the unroofing of vesicular or bullous lesions, or from necrosis due to ischemia (see Chapter 24 for rheumatoid vasculitis).

A B

Figure 7-23 **A:** A slightly hyperpigmented segment of "railroad tracks." If you cannot see it, look at the diagram in **(B)**. Pigmentation over the veins has also been reported in severe malnutrition, pellagrous dermatitis, stasis dermatitis, and injury to the veins following the injection of nitrogen mustard (Bean, 1976). (From Sapira JD. The narcotic addict as a medical patient. *Am J Med.* 1968;45(4):555–588, with permission).

Figure 7-24 The Pachuco mark, a sign of sociopathy, that can also be an identity card in some criminal segments of society. That is, someone from the drug-using demimonde can help establish his credentials as a member of the subculture by displaying his tattoo on entering a strange community. For someone seeking to buy illegal drugs, the tattoo serves the same purpose as a credit card or a curriculum vitae does for a traveling professor. (From Sapira JD. The narcotic addict as a medical patient. *Am J Med.* 1968;45(4):555–588, with permission)

Figure 7-25 The "necklace" of heroin use is composed of individual cigarette burns. The smoking heroin user nods off during the drug effect, and the head, cigarette in the mouth, falls forward. The burn is not perceived because of the analgesic effect of the heroin, as demonstrated by the length of some of the scars. This is a very early, yet common form of the necklace; a full-blown form would be composed of 15 or 20 individual burns. (From Sapira JD. The narcotic addict as a medical patient. *Am J Med.* 1968;45(4):555–588, with permission.)

Figure 7-26 The scars in the palm of this heroin user have the same basic pathophysiology as the necklace. This unusually neat heroin user did not like to spill his cigarette ashes on the floor and so used his hand as an ashtray. The good analgesic effect of the heroin is shown by the degree of scarring. (From Sapira JD. The narcotic addict as a medical patient. *Am J Med.* 1968;45(4):555–588, with permission.)

The early lesions of *pyoderma gangrenosum*, which may appear following minor trauma, consist of pustules, vesicles, boils, or inflammatory nodules, which rapidly break down to form burrowing ulcers. The advancing, irregular border is raised, purple-red, and undermined. Large areas of the abdomen, trunk, and extremities may become involved.

More than a third of cases of pyoderma gangrenosum occur in association with inflammatory bowel disease (ulcerative colitis or regional enteritis), and about another third occur in association with immune arthritis, although there is some overlap between these two groups. In about 30% of cases, there is no underlying disease. The few remaining are accounted for by a wide variety of seemingly unrelated disorders including multiple myeloma, biliary cirrhosis, malignancy, thyroid disease, pulmonary disease, systemic sarcoidosis, diabetes mellitus, spider bite, and iodine ingestion (Walling and Sweet, 1987).

The lesion must be differentiated from fungal lesions (histoplasmosis, blastomycosis, cryptococcosis, sporotrichosis, mucormycosis, and candidiasis), vascular lesions, neoplasms, and acute neutrophilic dermatosis (Sweet disease).

Lupus profundus is the panniculitis that supervenes in 2% to 3% of cases of systemic lupus erythematosus (Diaz-Johnson et al., 1975; Tuffanelli, 1971). Beginning as nodules, these break down and leave full-thickness ulcers, as if a punch biopsy had been performed with an odd-shaped punch (Fig. 7-27). Healing is from the edges, often leaving pigment behind.

Factitious Lesions and Delusions of Parasitism

Factitious lesions are consciously produced by the patient with the intent to deceive. There may be deep lacerations, burns, blisters, ulcers, purpuric lesions, or any other traumatically induced lesions. Generally, these lesions follow no distribution consistent with anatomic factors, tend to be within easy reach, and are often of similar shape (perfectly round or angular).

Figure 7-27 Ulcerated lesions of lupus profundus or lupus panniculitis in a patient with well-documented systemic lupus erythematosus. (Photograph courtesy of Dr Chester Danehower, with permission.)

When patients with suspected "autoerythrocyte sensitization purpura" were carefully observed, some were found to be inducing the lesions, although they would deny this both before and after the fact (Levin et al., 1969; Stefanini and Baumgart, 1972). (Of course, no patient can be truly observed for 24 hours, especially under conditions in which both hands are visible at all times.) Moreover, with this condition, skin that is out of reach of the patient's mouth or fingers, such as that in the interscapular area, is never afflicted. Furthermore, that skin can become involved when it is transplanted to an accessible area (Schwartz et al., 1962), and previously involved skin becomes "disease resistant" when transplanted to the interscapular area. Bandaging or casting an area (Levin et al., 1969; Stefanini and Baumgart, 1972) is another effective and less draconian method of conferring "resistance." Such investigations would be expected to yield similar results with other factitious lesions.

In delusions of parasitism, the patient admits to picking or scratching the skin but insists it is to remove ectoparasites, which the patient often asserts have been visible. Often, patients will bring in bits of excoriated skin debris for microscopic examination, which is universally unrevealing (D. Printz, *personal communication*, 1998).

Findings on Palpation

Texture

The skin of primary hypothyroidism is coarse and dry. In contrast, hypothyroidism secondary to panhypopituitarism may be

associated with fine skin, which may appear wrinkled like cigarette paper. Patients under 50 with hyperthyroidism have warm, moist, fine skin, likened to that of a baby. Patients with acromegaly have excessive sebaceous activity, resulting in a greasy or waxy feel to the skin. (Patients who have coincidental facial resemblance to acromegaly but no greasy skin tend to have normal growth hormone studies.) Parkinsonian patients also have greasy skin. The skin texture in scleroderma is described under "Sclerodactyly" in Chapter 24.

Scleredema adultorum of Buschke is a hard, nonpitting skin that cannot be picked up by the examiner's fingers. It begins as an induration on the posterior neck and then spreads to other areas in the distribution of the superior vena cava. Those cases that follow infection usually remit, but those that occur in the diabetic may persist (Cohn et al., 1970).

Skin thickening that may remind the clinician of scleroderma is found in Crow–Fukase syndrome. The skin is taut, but not hidebound, so that it can be lifted although the patient may not be able to make a fist. Other skin changes include diffuse hyperpigmentation, hypertrichosis, hyperhidrosis, and edema. The skin changes may be of great value in leading to the diagnosis of plasma cell dyscrasia and to timely treatment before the patient becomes wheelchair-bound owing to polyneuropathy. The acronym POEMS, also applied to this syndrome, stands for *p*olyneuropathy, *o*rganomegaly (hepatosplenomegaly), *e*ndocrinopathy (hypothyroidism), *M*- proteins, and *s*kin changes (Shelley and Shelley, 1987).

Sclerodermatous changes may be a manifestation of chronic graft versus host disease. These include thickened, tight, fragile skin associated with poor joint mobility (Bushan and Collins, 2003).

Turgor

Skin turgor is traditionally tested for by plucking up a fold of skin and observing whether it tents ("poor turgor") or returns to normal ("good turgor"). Poor turgor is now equated with dehydration. It is one of the best signs for assessing hydration in children. The recommended method is to use the thumb and forefinger to pinch a small skin fold on the lateral abdominal wall at the level of the umbilicus, promptly release, and measure the time it takes to return to normal. There are no clear norms, and most clinicians describe the time as "immediate," "slightly delayed," or "prolonged." The positive likelihood ratio is 2.5 (Steiner et al, 2004).

There is an important caveat: Although this sign works well for young people with normal elastic fibers, for old people it may only work on forehead skin, which for some reason retains its elasticity for a long time. Try comparing the forehead turgor with the gingival–labial fold moisture (see Chapter 13).

Temperature

Throughout this work, the student is instructed to palpate the skin overlying various portions of the body. When comparisons can be made between the sides, it is assumed that some pathologic process is occurring on one side but not on the other. However, if the patient has been lying in a decubitus position or if one portion of his body has been covered and not the other, the retained heat can produce a false positive. Accordingly, you should not check for skin temperature until the patient has been under your observation for some time.

One can assess temperature differences best by palpating with the dorsal surfaces of one's index and middle fingers (J. Scherzer, *personal communication*, 1998).

For the significance of skin temperature in assessing perfusion, see Chapter 18.

Special Maneuvers

Dermographism

Dermographism is an exaggeration of the normal response (wheal and erythema) to cutaneous trauma. Writing on the skin with a dull point gives rise to raised letters, white in the center with red margins. It may be associated with atopic disease, or it may simply be a curiosity. According to *French's Index of Differential Diagnosis* (see Chapter 29), it is to be distinguished from tache cérébale lines that are wholly red, developing within 30 seconds of drawing a fingernail across the skin with moderate firmness. Tache cérébale was said to be characteristic of tuberculous meningitis but can also be seen in other severe febrile illnesses or even in healthy people (Hart, 1979).

Koebner Phenomenon

If an old established skin lesion appears to "jump" to a new *noncontiguous* location following trauma to that previously normal-appearing skin, the lesion is said to exhibit the Koebner phenomenon. This has been traditionally associated with psoriasis, lichen planus (see Chapter 13), and a number of rarer dermatoses. However, it is not highly diagnostic, and it has even been reported in the eruptive xanthomas of hyperlipidemia (Barker and Gould, 1979).

A schoolboy once wrote the name of his beloved with a compass on the extensor surface of his arm during a boring geometry class. At the time of the infatuation, the name remained private. However, he later developed vitiligo, which made the girl's name visible in a dramatic manifestation of the Koebner phenomenon (Sweet, 1978).

The Nikolsky Sign

In patients with the Nikolsky sign, a firm lateral pressure on unblistered skin will produce a sliding of the superficial layers of the epidermis over the deeper layers. In normal persons, this sign cannot be elicited. (Try it on yourself.)

The test is not highly specific; an early biopsy of perilesional tissue, with direct immunofluorescent staining, is preferable to reliance on this sign.

The test reflects disease activity because clinical and serologic remission is often accompanied by reversion of the sign to normal.

Two Israeli dermatologists accidentally discovered a modification while attempting to test for dermographism by stroking with the round end of a paper clip (Hacham-Zadeh and Even-Paz, 1980). The paper clip is held at a 45-degree angle to the firmly stroked skin. A smaller, less painful Nikolsky sign can be produced in this way.

This sign has been used by dermatologists to differentiate Nikolsky-positive pemphigus vulgaris from Nikolsky-negative bullous pemphigoid. In the latter, biopsies reveal not the sliding of one layer of the epidermis on another but rather a sliding of the entire epidermis upon the dermis (Grunwald et al., 1984). Not unexpectedly, this has been christened the pseudo-Nikolsky sign. It takes some experience to appreciate the difference.

Given the confusion among the experts concerning this sign throughout its history, which is not detailed here, one is tempted to quote Thomas "Fats" Waller's reply to the society lady who asked him to explain syncopation. "Lady," he said, "if you don't know what it is, you ain't got no business messing with it."

Transillumination

If a penlight is placed against one side of a lump and the light can be seen from the other side, we say that the lump is translucent, or, vulgarly, that it transilluminates. (Actually, the penlight transilluminates.) Cysts, lipomas, chondromas, and xanthomas may transilluminate in this sense.

Odor

An unpleasant odor is associated with certain skin conditions, including infected eczema, hidradenitis suppurativa pemphigus, herpes labialis and herpes zoster, and Darier disease. Leg ulcers that have become infected may emit an unpleasant odor. A *Pseudomonas* skin infection produces a musty odor, as do some cancers, possibly from the sweat.

The sweat in scurvy is said to have a putrid odor, and patients with scrofula are said to smell like stale beer. In maple syrup urine disease, the sweat smells like maple syrup, and in hypermethioninemia, it smells like fish, rancid butter, or boiled cabbage (Hayden, 1980).

The sweat of some schizophrenic subjects, but not that of normals, contains *trans*-3-methyl-2-hexenoic acid, adding weight to the theory that schizophrenia may be an inborn error of the metabolism. To help doctors assess doubtful cases by the patient's odor, a mental hospital in Australia in the 1920s provided a special room that was freshly whitewashed after use. Only in 1960 was it demonstrated that rats could distinguish the sweat of some schizophrenics from that of nonschizophrenic subjects (Liddell, 1976).

Other odors are discussed in Chapter 13.

Abnormalities of Sweating

Various sweat tests are described in Chapter 26. Localized areas of hyperidrosis may occur in neurologic disorders. A localized area of continuous sweating (most commonly involving palms, soles, axillae, and genital regions) may be a symptom of postencephalitic parkinsonism. Palmar or plantar hyperidrosis may be a manifestation of an anxiety disorder.

In anidrosis, which is rarer than hyperidrosis, sweating may be diminished or totally suppressed. Either the entire skin or certain areas may be affected. It may occur in ichthyosis. Suppression of sweating is characteristic of heatstroke and may occur with destruction of certain areas of the hypothalamus (*French's Index of Differential Diagnosis* [Hart, 1979]).

Hair

The examiner should note the hair distribution, texture, and appearance.

(I do not examine individual hairs unless I am considering the diagnosis of scurvy [as discussed later in this chapter].)

Distribution

Sexual Hair

Three sites of body hair should be examined for clues to the patient's endocrine status: the face, the axilla, and the pubic region.

Face

Sexual hair formation is stimulated by androgens, so facial hair may occur in some women with a constitutional predisposition (e.g., androgen receptor sensitivity) or as a sign of elevated androgen levels. Conversely, in men, damage to the testes or the development of gonadotropic insufficiency for any reason will cause the facial hair to become sparse and slow growing.

Because of the normal constitutional variability, a good history is necessary for interpreting the physical findings. *Change* is more important than the actual amount of hair. In some women of Mediterranean background, a significant amount of facial hirsutism may be quite normal, and among Amerindians and some Asians, very sparse facial hair is the norm in men.

Axilla

In both men and women who are hypogonadotropic, the axillary hair will slow its growth and become sparse compared with the baseline.

Before the development of good assays for gonadotropic hormones, research subjects participated in the bioassay of experimental preparations by weekly measurements of the weight of their shaved, acetone-defatted axillary hair (and in the case of men, facial hair also).

Pubis

The shape of the pubic hair distribution is called "female" if it forms a triangle with the apex pointed toward the perineum and "male" if it is in the shape of a diamond, with the superior tip of the diamond pointing to the umbilicus. It responds to the excess or lack of androgens effect on hair in the same way as the other sexual hair described above (see also Chapter 22).

Eyebrows

Thinning of the lateral third of the eyebrows is a form of local acquired alopecia that is suggestive of the diagnosis of hypothyroidism. Eyebrows that are sparse laterally and normal medially are called *Queen Anne's eyebrows*, although portraits of various Queen Annes do not show this finding except possibly during a period (1707–1714) in which it was fashionable to shave the lateral third of the eyebrows.

In addition to hypothyroidism, causes of lateral thinning of the eyebrows include trichorhinophalangeal syndrome, trichodental syndrome (Fitzpatrick et al., 1979), leprosy ("Bailey's" [Clain, 1973]), normal aging (De Groot et al., 1984), and subacute thallium intoxication (Grunfeld and Hinostroza, 1964).

Systemic lupus erythematosus may cause total loss of the eyebrows, not just of the lateral third, as may syphilis (Fitzgerald, 1982).

Eyebrow pencil may obscure these findings, unless one looks closely.

Once I was shown a patient with a low serum thyroxine, in whom Queen Anne's eyebrows were the only evidence of hypothyroidism that could be found on the physical examination. Alas, they were constitutional, not acquired, and the low serum thyroxine was eventually ascribed to the euthyroid sick syndrome. This illustrates an important principle, especially in regard to general appearance,

facies, skin, habitus, and, in this case, hair. If at all possible, have the patient or a member of the family bring in an old snapshot or, even better, the family photograph album.

Chronic contraction of the orbicularis oculi causes the eyebrow to be below the superior orbital rim in blepharospasm, whereas the eyebrow is positioned normally in apraxia of lid opening (Jones et al., 1985).

Hair on the Feet

Loss of hair on the toes, feet, and ankles has been presented as evidence of arteriolar sclerosis or diabetes mellitus. However, when 40 patients with diagnosed arterial occlusive disease were compared with 40 controls, no difference was found in any measure regarding hair on the toes and anterior shins (Parfrey et al., 1979).

Alopecia

The causes of hair loss are legion. To shorten one's library time, I suggest describing alopecia as diffuse or patchy. In the case of patchy hair loss, one should also describe it as occurring with normal-appearing scalp or secondary to scarring or lesions of the scalp. Also, ascertain whether the hair breaks off or comes out by the roots. Always obtain a drug history, as a large number of commonly used drugs can, in a minority of patients, suppress hair follicles.

Many patients with diffuse alopecia will wear a wig, which must be noticed and removed by the examiner. Removing turbans and wigs is always necessary to permit examination of the scalp. I once missed an obvious case of herpes zoster (in a patient I allowed to be presented while she was receiving a shampoo) because I believed the house officer's incorrect description of a bilateral pustular lesion, when there was actually a unilateral herpetic one.

Diffuse hair loss may be seen in hypothyroidism, panhypopituitarism, hyperthyroidism, some cases of hypoparathyroidism, lupus erythematosus (Fig. 7-28), heavy metal toxicity (e.g., thallium), and as a sequel to treatment with retinoids (Goldfarb et al., 1987) or certain drugs used to treat hyperthyroidism or cancer. Rarely, substantial hair loss has followed the administration of vaccines, especially hepatitis B; some cases had a history of recurrence on rechallenge (Wise et al., 1997). The scalp will appear normal. Currently, the most common cause of complete alopecia (total baldness) is cancer chemotherapy.

The most common cause of patchy hair loss with normal-appearing scalp is alopecia areata, a disease that has kept many preminoxidil hair restorers in business by providing dramatic visual "proof" through before-and-after pictures (although the alopecia is irreversible in some cases). Female patients with alopecia areata may cover their hair but tend not to buy wigs. Alopecia areata does not necessarily imply presence of another disease. If it is found to be associated with clinically significant autoimmune disease, that will probably be autoimmune thyroiditis, although occasionally one may find diabetes mellitus or vitiligo in this setting (J. Scherzer, *personal communication*, 1998). White hair may be spared in adults. The sudden whitening of the hair of General Charles Gordon, British commander at the siege and fall of Khartoum, Sudan, in 1885, may have been a case of stress-induced alopecia areata (Schwartz and Janniger, 1997).

Figure 7-28 Alopecia associated with systemic lupus erythematosus. (Photograph courtesy of Dr Chester Danehower, with permission.)

Figure 7-29 Alopecia in secondary syphilis. (Photograph courtesy of US Public Health Service. *Syphilis: A synopsis.* Public Health Service Publication No. 1660, January 1968, with permission.)

Alopecia areata is to be distinguished from the "moth-eaten" hair loss, beginning in the occipital region and often accompanied by loss of eyelashes and the lateral third of the eyebrows (Fig. 7-29), that may be seen in secondary syphilis.

Patchy hair loss with scalp lesions is seen in tuberculosis, systemic lupus erythematosus, and sarcoidosis (Fig. 7-30), *inter alia*.

The male vertex balding pattern is strongly associated with syndrome X diseases such as coronary artery disease and hypertension and might be promoted by the high–glycemic-load carbohydrates that induce hyperinsulinemia (Cordain et al., 2003).

Patients who pull their hair out may benefit from psychiatric consultation and also from a gastrointestinal consult for a possible bezoar if they also eat the hairs, as did the patient shown in Fig. 7-31).

Color

Canities (graying of the hair) occurs in pernicious anemia, with chloroquine treatment, and in some of the etiologies of vitiligo. Poliosis (premature canities) occurs in patients with thyroid disease and their kindreds.

Figure 7-30 Scarring alopecia in sarcoidosis. Sarcoidosis frequently mimics other skin diseases. (Photograph courtesy of Dr Chester Danehower, with permission.)

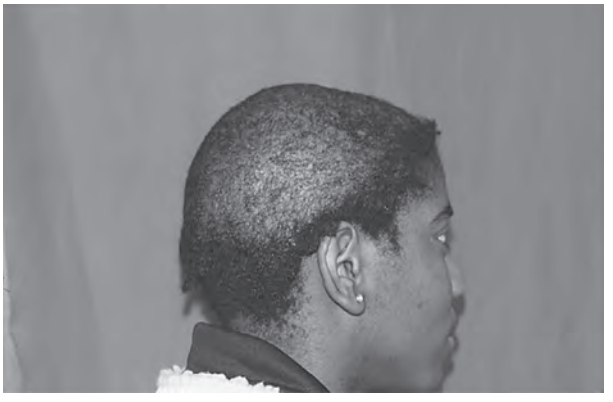


Figure 7-31 This patient has trichotillomania. She pulled out her hair. The remaining hairs are frequently of varying length. (Photograph courtesy of Dr Chester Danehower, with permission.)

Brown hair in Asians may be a sign of protein calorie deficiency, or of phenylketonuria, but can also result from exposure to chemicals such as swimming pool chlorine or cosmetics.

Scalp hairs in tinea capitis caused by *Microsporum canis* and *M. audouini* display a green fluorescence under Wood's light. Interestingly, *Trichophyton tonsurans*, the cause of 96% of tinea capitis in the pediatric age group, does not usually cause fluorescence (J. Scherzer, *personal communication*, 1998).

Texture

The hair is very fine in hypermetabolic conditions such as hyperthyroidism and in some patients with chronic obstructive pulmonary disease. Coarse hair is found in hypothyroidism. Brittle hair occurs in Menkes (kinky hair) syndrome, an X-linked disorder characterized by defective copper absorption. The hair is also coarse and lacks in pigment, and the eyebrows are horizontal (Stewart and Rosenberg, 1996a). Brittle hair also may be a sign of chronic graft versus host disease, along with premature graying, alopecia, and decreased body hair (Bhushan and Collins, 2003).

Appearance

Corkscrew hairs on a background of perifollicular hemorrhages (Fig. 7-32) are pathognomonic for scurvy provided that they occur in persons who do not normally have corkscrew hairs (i.e., in straight-haired people) and in parts of the body where the hairs are not normally curled (i.e., on the arms and legs but not in the pubic areas of those with naturally curly pubic hair). The etiology and semeiophysiology of this type of hair can be deduced from Fig. 7-33.

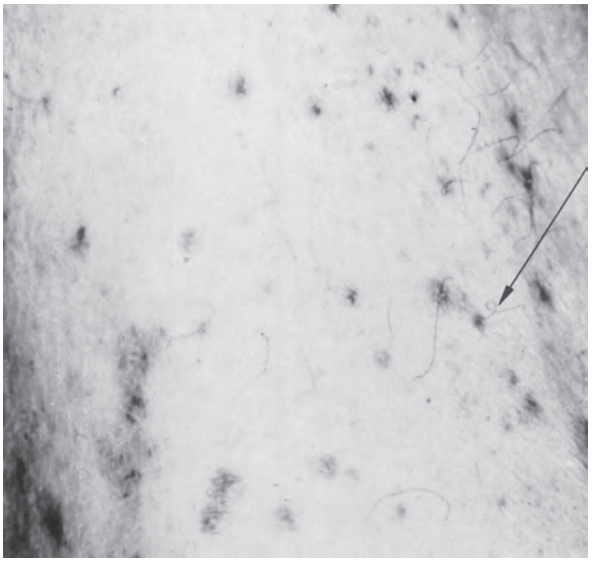


Figure 7-32 Corkscrew or pigtail hair on a background of perifollicular hemorrhages in a patient with scurvy. What other characteristic hemorrhage is seen in this disease? (From *Consultant Magazine*, Cliggott Publishing Company, Greenwich, CT, with permission.)

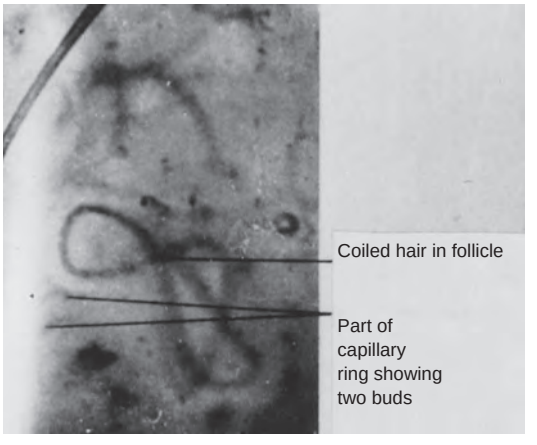


Figure 7-33 During the first phase of scurvy when follicular hyperkeratosis supervenes, the mouth of the hair follicle becomes plugged. But the hair continues to grow within it, becoming curled up. This is shown as "coiled hair in follicle" in microphotos of the hair follicle of a World War II conscientious objector who volunteered for the world's only double-blind experimental scurvy study. (Half the volunteers were given vitamin C and half placebo tablets as a supplement to their scorbutic diet.) When the follicle's plug is eventually knocked loose, the coiled hair springs out fully formed, like Zeus's wife, from his head. There is nothing intrinsically wrong with the hair itself; its odd form is due to growing in a plugged follicle. (From Vitamin C Subcommittee: *Microphotograph of Hair Follicle in Patient with Scurvy*, Medical Research Council Special Report, Series No. 280, Controller of Her Britannic Majesty's Stationery Office, 1953, with permission.)

False positives have been seen in situations (e.g., thrombocytopenia) in which the follicles have become plugged with blood, but this phenomenon is restricted to areas of hemorrhage.

Nails

From the fingernails, an astute clinician can make meaningful estimates of the results of laboratory tests such as the hematocrit, serum albumin, and blood urea nitrogen. In addition, the nails give clues to various congenital anomalies as well as to numerous systemic diseases.

Color of the Nail Bed

Acrocyanosis

Cyanosis may result from deoxyhemoglobin, methemoglobin, or sulfhemoglobin, as previously noted. Slowing of the peripheral circulation as in erythrocytosis may cause acrocyanosis while the rest of the body remains pink. Local venous disease can produce focal acrocyanosis.

Pallor

With practice, one can estimate the hematocrit to within a few points by simply examining the nail beds.

In one study, the sensitivity of the sign of nail bed pallor was found to be 59%, the specificity 66%, and the positive LR 1.6 (Nardone et al., 1990). This indifferent performance could, however, represent the Law of Chopin—I cannot play Chopin at all, but others can play his music very well (Sapira, 1990). How much had the examiners in this study practiced?

Self-study

The best way to learn to recognize and quantify pallor is to go to the medical ward and look at a patient's fingernails. Estimate the hematocrit, committing yourself in writing, and then look up the measured hematocrit. Repeat at the next bed. By the time you have been once around the ward, you should be pretty accurate. (Note that the electronic counter does not measure the hematocrit but rather calculates it from the red cell count and the mean corpuscular volume, and this reported hematocrit may be inaccurate by three to five points.)

Even if you miss the hematocrit by a few points most of the time, it does not matter. What you want to know is whether the patient has anemia or not. Whether the hematocrit is actually 20, 24, or 28, you will proceed to evaluate the anemia.

False Positives

In patients with leukonychia or if the fingernails congenitally compress the distal nail bed vasculature, the nails look pale despite a normal hematocrit. The latter phenomenon can be detected by lifting the nail from the nail bed and observing the filling phenomenon. Nail bed pallor is also seen in the vascular insufficiency of shock and of arterial obstruction.

One can also routinely estimate the hematocrit from the conjunctivae, oral mucosa, and tongue (Jacobs et al., 1979) to obviate such interfering circumstances of the nail beds. A study that compared the pallor of the conjunctivae, nail beds, and palmar creases with a tint scale made from a color tint selector showed a significant correlation (Strobach et al., 1988).

A patient was presented with a stated hematocrit of 39. He looked quite pale, and his nail beds were pale. All agreed that he was paler than on admission. I announced that the stated hematocrit must be wrong, and I was confronted with an identical repeat value. I took the patient to the sunlight and examined his conjunctivae, which were also quite pale, so I bet a lunch. The next morning I was presented with another electronic hematocrit of 39 and also a spun hematocrit of 39. Puzzled, I went back to look at the patient, who was now quite pink, as were his nail beds and conjunctivae. When I told him what puzzled me, he stated that he often became pale under circumstances of excitement or fright.

"You mean," I asked, "that when we all came in here the other morning to examine you, you became upset."

"Yes," he said.

"Oh," I said. "That's what caused the pallor."

The patient looked up at me and smiled. "You didn't know you were that ugly, did you?" he laughed.

Moral: *When all else fails, go back and ask the patient.*

False Negatives

Many nonwhites have sufficient pigmentation in their nail beds to prevent the appearance of pallor even in the presence of a low hematocrit. (This was first pointed out to me by Dr Bruce Singh of Australia and was emphasized by Dr Liz Torres of Texas.) This error can be avoided by inspecting the degree of redness and ignoring the total amount of pigmentation.

Lighting

Another common cause of difficulty is the use of indoor lighting. The most accurate predictions of hematocrit values are made in direct sunlight (see similar comments on scleral icterus, Chapter 10). To convince yourself of the truth of this statement, on a bright, sunny day, examine several patients under incandescent lights in an inner hallway, and then immediately walk them to a window where their hands can be examined in direct sunlight.

Abnormalities of the Nail

Examine all ten fingernails and all ten toenails. If there are discolorations, observe the effect of blanching the nail or of illuminating with a penlight placed against the finger pulp. If you find some of the changes described below that may be associated with systemic disease, measure the distance from the cuticle to the leading edge of the change. As the rate of nail growth is from 0.1 to 0.15 mm per day, this may give the approximate time of the initial insult.

Leukonychia Totalis

Leukonychia totalis (a completely white nail) may result from a variety of causes (Zaias, 1980), listed in Table 7.6.

Some of the familial cases of leukonychia totalis may also have knuckle pads and deafness in a dominant pattern (Bart and Pumphrey, 1967). Others have multiple sebaceous cysts and renal calculi (Zaias, 1980).

TABLE **7.6** *Differential diagnosis of leukonychia totalis*

Familial
Autosomal dominant

Local dystrophic disease
Leprosy
Herpes zoster
Fungal infection
Trophic diseases of the upper extremity

Systemic diseases
Adrenocortical insufficiency
Cancer chemotherapy
"Cardiac insufficiency"
Exfoliative dermatitis
Hodgkin disease
Pneumonia
Tuberculosis
Trichinosis
Chronic arsenic poisoning
Hepatic cirrhosis

Nutritional deficiencies
Zinc deficiency
Pellagra
Hypoalbuminemia, chronic
4% to 7% of normal persons (Harrington, 1964)

From Terry R. White nails in hepatic cirrhosis. *Lancet.* 1954a;1:757–759 and Zaias N. *The Nail in Health and Disease.* New York: Spectrum Publications; 1980, with permission.

Incomplete Leukonychia

Incomplete leukonychia, in the form of bands or spots, may be acquired or inherited. The etiologies include trauma, heavy metal poisoning, typhoid fever, ulcerative colitis, and, for unknown reasons, myocardial infarction in some patients.

Transverse White Bands

Mees lines, seen in arsenical polyneuropathy, consist of a single transverse white band (Mees, 1919). The same transverse single bands, when they occur in infectious fevers, are called *Reil lines*. Without an eponym, these same bands have been seen in acute and chronic renal failure, thallium toxicity (Grunfeld and Hinostroza, 1964), leprosy, malaria, fluorosis, psoriasis, cardiac insufficiency, pellagra, Hodgkin disease, pneumonia, myocardial infarction, and sickle cell disease (Hudson and Dennis, 1966). (Given the excess of causes over eponyms for what is essentially the same sign, the ambitious student may wish to attach his own name to some eponymously vacant etiology.)

Hypoalbuminemia, especially if intermittent, may also cause white transverse opaque bands. A pair of transverse lines (Fig. 7-34) were described in hypoalbuminemic patients suffering from the nephrotic syndrome (Muehrcke, 1956). These lines are said to be pathognomonic for hypoalbuminemia (Conn and Smith, 1965).

Other Transverse Bands in the Nail

Periods of intermittent catabolism due to fever, cachexia, malnutrition, and so forth will produce Beau lines: nonpigmented indented transverse bands best seen in oblique light. These were first described by Hiller (Wilks, 1869).

No false positives could be seen if Beau lines were defined as transverse grooves running across the greater part of each nail and occurring simultaneously in all (Robertson and Braune, 1974).

Yellowish bands can be seen after parenteral gold therapy (Fam and Paton, 1984).

Nail Bands as Calendars

Most of these bands (but not Muehrcke lines) can be used to time an illness by noting their distance from the proximal nail bed. The nails of the upper extremities grow out in about 120 days (Bean, 1968). However, the rate of growth slows with age and with local afflictions of the nail bed as well as with systemic diseases. Toenail growth is much slower than fingernail growth.

Half-and-Half Nail

The half-and-half nail (Lindsay, 1967) consists of a nail whose proximal portion is white to pink and whose distal portion, always well demarcated, is a dirty red or brown. Originally believed to be a sign of chronic renal disease, in some populations, it is much more commonly seen with chronic hepatic failure. The finding is not necessarily abnormal in toenails.

Pigmentary Changes

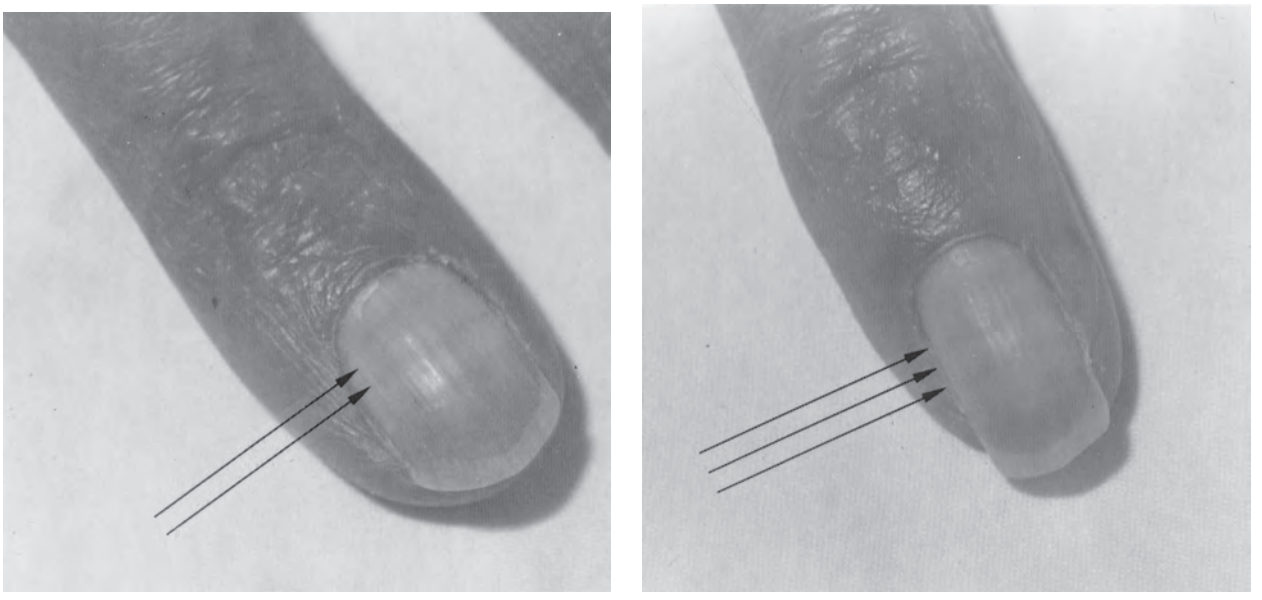
Darkening of the nails has been reported with many chemotherapeutic drugs (Furth and Kazakis, 1987), including azidothymidine, bleomycin, doxorubicin, fluorouracil, melphalan, nitrogen mustard, nitrosoureas, methotrexate, cyclophosphamide, and mitoxantrone (Speechly-Dick and Owen, 1988). Black nails have been seen after radiation and exposure to photographic developer and hair dye, as well as in Peutz–Jeghers disease, vitamin B_{12} deficiency, malignant melanoma, and pinta.

Green nails have been seen with *Pseudomonas* infection (Fitzpatrick et al., 1979). Also see "yellow nail syndrome" later in this chapter.

The Lunula

The lunula should be sought on the thumbnail, where normally it is easily observed. (On small nails with abundant cuticles, the lunula may not be so apparent.) The lunula disappears or undergoes "reversal" in catabolic and hypoalbuminemic states. Reversal refers to a red lunula with a white distal nail. (The latter is the second type of Terry nail.)

The Terry nail has caused an unrecognized confusion because Terry published two articles on two different abnormal fingernails in the same journal and year (Terry, 1954a,b). In the first, he described the white nails of hepatic cirrhosis. Although the distal few millimeters were usually pink, the lunula was usually obscured. This Terry nail was observed in 82% of patients with hepatic cirrhosis. Additional causes were chronic congestive heart failure, diabetes mellitus (especially in the young), pulmonary tuberculosis, rheumatoid arthritis, viral hepatitis in convalescence, multiple sclerosis, Crow–Fukase syndrome (*vide supra*) and some forms of



A B

FIGURE 7-34 While there is no reason that someone could not be twice poisoned with arsenic, Mees lines are usually single. Double bands **(A)** are generally Muehrcke lines and diagnostic for hypoalbuminemia, in that they may be reversed with albumin infusions without waiting for the nail to grow out. Thus, they are not in the nail itself as the other lines are but are in the nail bed. Accordingly, they do not grow out with the nail like the other bands do and thus cannot be used for timing illness. A triple Muehrcke line **(B)** was found in a patient with an albumin of 3.1 g per dL, below normal but above the ceiling of 2.2 g per dL given in the original paper (Muehrcke, 1956). What other sign of disease do you see here? Where are the lunulae? (See "Terry Nails" in text.) One trick useful to see the lines is to concentrate on the dark bands separating the light Muehrcke lines.

carcinoma. A few apparently healthy children and adolescents also had these nails.

In the second type of Terry nail, the lunula was suffused a deep red. More than half the patients with this finding suffered from congestive heart failure. The rest had pulmonary disease, cirrhosis, polycythemia vera, malnutrition, Hodgkin disease, or other lymphoma. This type of Terry nails was specifically sought and not found in 150 healthy young women nor in patients with nonsystemic diseases such as hernia or peptic ulcer.

To update the confusion, Terry nails, by modified criteria, were found in about 25% of 512 consecutive hospitalized inpatients. The key and earliest feature was a distal brown to pink band from 0.5 to 3.0 mm wide, caused by telangiectasia in the upper dermis of the nail bed. The pallor of the proximal nail appears to develop later and might or might not obscure the lunula. The risk of cirrhosis, chronic congestive heart failure, or type 2 diabetes mellitus was 2.69 times greater for patients of any age with Terry nails than for those without and 5 times greater for patients 50 years of age and younger (Holzberg and Walker, 1984).

A bluish discoloration of the proximal portion of the nails is termed the *azure lunule*. It has been seen in *Pseudomonas* infections of the nails, Wilson disease (Bearn and McKusick, 1958), and argyria (Gulbranson et al., 2000), as well as following: the local application of mercury or therapy with quinacrine, chloroquine, or phenolphthalein (Whelton and Pope, 1968).

Longitudinal Lines

Splinter hemorrhages in the fingernail beds have their long axes parallel to the long axis of the finger. Their color should be described. Broad (greater than 1 mm in width), red splinter hemorrhages are seen in trichinosis, Darier disease, psoriasis, or infective endocarditis (in which they result from embolic material or large antigen–antibody complexes). Thin (less than 1 mm in width), black or brown splinter "hemorrhages"—often in the nail, not the nail bed—are most commonly due to incidental trauma and are seen in manual laborers.

Splinter hemorrhages (color unmentioned) have been reported in 10% to 66% of all hospital admissions (Bishop et al., 1981; Kilpatrick et al., 1965) and in from 0% (Platts and Greaves, 1958) to as many as 56% of normals (Robertson and Braune, 1974). Thus, "splinter hemorrhages" of unspecified color are not pathognomonic for endocarditis, although many think so.

In more than 25 years of carefully examining the fingernails of all comers, I have never seen anything like the figures of up to one in four that have been reported for a broad range of common diagnoses. Thus, these reports must be referring to the incidental thin brown and black splinters that are of little use in the diagnosis of endocarditis or anything else. In the literature, as far as I have been able to find, the critical distinction is not made between these "splinters" and the rare, highly diagnostic broad red type.

Brown or black streaks, too wide to be splinter hemorrhages (1 mm or more), have been reported in chronic primary adrenocortical insufficiency (Bondy and Harwick, 1969) but may also be seen normally in highly pigmented persons: longitudinal melanonychia is said to occur in 77% of black persons over the age of 20 years and almost 100% of those over the age of 50. There is also a long differential diagnosis, of which a subungal melanoma is the most lethal (Bodman, 1995). Note that melanomas generally enlarge radially

with pigment seeping into adjacent structures like the proximal nail fold (the Hutchinson sign), whereas subungal hematomas should grow distally about 1 mm per month. Variations in nail pigmentation should be accurately measured and recorded (Bodman, 1995).

Pits

Deep wide pits (about 5 mm in size) are diagnostic of psoriasis. Small "pits" in the nail, 1 mm or less in size, are seen in psoriasis and many other conditions. These include Reiter syndrome, pityriasis rubra pilaris, acrodermatitis continua of Hallopeau, psoriasiform acral dermatitis, parakeratotic dermatitis, hyponychial dermatitis, and alopecia areata, and they are also seen in some normal individuals (Zaias, 1980).

A Pedagogic Note for Sophomores. This list, like others, is for reference, not for memorization. It certainly is an impressive list of diseases. But if the truth be known, I have only seen pitting of the nails in psoriasis and in the last entry on the list. In fact, I have never seen (or recognized) most of the diseases listed. There are a few I have never even heard of before.

This note is for sophomores only because they have not yet acquired the perspective that comes with experience. More advanced students have already come to appreciate the lamentation of Hippocrates: "The art[3] is long, and life is short."

The reader may well ask whether other authors and other compilers of lists sometimes describe that which they have not seen. Yes. That is called scholarship. Do some lists comprise secondhand information? Yes. Does that mean that some of the entries on the list may be wrong? Yes. Also, are the lists incomplete? Yes, it must be so. Why, then, should one read the literature?

Hippocrates also wrote that "experience is deceiving." It can only be corrected by further experience. The person who reads critically and assiduously will vicariously increase his experience exponentially and thereby increase his ability to correct his own errors.

Dystrophic Nails

Onycholysis

Onycholysis is a separation of the distal nail from the nail bed, averaging at least a millimeter or more in length. Excluding local dermatoses and fungal infections of the finger, it is seen in hypermetabolic conditions of which hyperthyroidism is the best known. It most commonly affects the fourth finger.

I have also seen onycholysis as a sequela of chronic amphetamine use and, very rarely, as a manifestation of chronic obstructive lung disease. In the latter, it could be owing to a hypermetabolic state produced by the increased work cost of breathing or by the phenylethylamines that such patients received. (In former years, the most popular phenylethylamine was ephedrine, which is hydroxylated methamphetamine.)

Onycholysis is also seen in some porphyrias and photosensitivities (Zaias, 1980), in psoriasis (with and without arthropathy), in Reiter syndrome, and after treatment with mitoxantrone, doxorubicin (Speechly-Dick and Owen, 1988), or captopril (Borders, 1986). A number of other associations have also been reported, including diabetes mellitus, systemic lupus erythematosus, scleroderma, multiple myeloma, and syphilis (Herzberg, 1995). There are a number of local causes, such as contact dermatitis and trauma (Bodman, 1995).

Onycholysis in association with a brownish discoloration of the distal third of the fingernails has been seen following erythematous photosensitivity induced by tetracycline (Segal, 1963). Onycholysis with greenish discoloration suggests *Pseudomonas* infection (Henggee and Bardeli, 2009), which may coexist with a candidal infection (Zaias, 1980).

Koilonychia

Koilonychia is Greek for "hollow nails"; we now call them *spoon nails*. The distal and lateral edges of the nail are lifted up so as to leave a valley or hollow in the center of the nail. This characteristic contour gives a neat operational definition: a spoon nail is sufficiently concave so that a drop of water placed on the nail will not roll off.

Koilonychia is best known as a sign of hypochromic anemia, being found in 4% of adult patients with iron deficiency anemia (Kalra et al., 1986).

The figures are somewhat different for infants: In a well-baby clinic, 22 out of 400 infants were found to have koilonychia (Hogan and Jones, 1970). Of these 22, 19 had iron deficiency (true positives) and three did not (false positives). Of 15 age-matched controls from the group of 378 patients without koilonychia, 3 had iron deficiency (false negatives) and 12 did not (true negatives). If we assume that the prevalence of iron deficiency among all the infants without koilonychia was the same as in the infants who were studied (i.e., 3 out of 15 or 20%), what is the prevalence of iron deficiency in the entire population of 400? The sensitivity of koilonychia for the diagnosis of iron deficiency? The specificity? The predictive value of a positive test? The predictive value of a negative test? The diagnostic accuracy? Make a 2×2 contingency table, as shown in Chapter 1. See Appendix 7-6 for the answer.

Koilonychia may also be familial (Bumpers and Bishop, 1980). It may be a marker of various congenital disorders, such as Turner syndrome or the leukonychia-renal calculi-multiple sebaceous cysts syndrome. It may be associated with other ectodermal findings, such as palmar keratoses, monilethrix, and steatocystoma multiplex (Leung, 1985). It may be acquired as a result of carpal tunnel syndrome, fungal infection, intestinal diseases, or thyroid dysfunction (Leung, 1985). It has also been associated with Raynaud syndrome, hemochromatosis, porphyria, and scleroderma (Herzberg, 1995). Finally, it may be occupational, caused by repeated mechanical trauma or exposure to organic solvents, as in hairdressers who frequently give permanent waves barehanded (Alanko et al., 1997).

Onychomycosis

Tinea unguium is characterized by nails that are thick, white, chalky, and crumbly. Although toenails are quite commonly afflicted in the elderly, the occurrence of onychomycosis in younger persons, especially if all ten nails are involved, probably signifies AIDS (D. Printz, *personal communication*, 1998). An even better sign of AIDS is proximal subungal onychomycosis (C. Danehower, *personal communication*, 2008).

Yellow Nail Syndrome

Yellow or yellow-green nails, which are also thickened, smooth, slow growing, excessively curved from side to side, and possibly

[3] Hippocrates used the word *techne*, which means art, profession, and craft, all at once.

onycholytic or ridged transversely, form part of a triad. The second part is lymphedema due to lymphatic insufficiency (see Chapter 25), and the third is pleural effusion with a high pleural fluid protein concentration (i.e., above 1.5 g per dL). Only two of the three findings need be present in any given case, so it is possible for a patient to have the yellow nail syndrome without the yellow nails (Eastwood and Williams, 1973; Hiller et al., 1972). The syndrome may also be associated with chronic infections of the upper and lower airways, such as sinusitis and bronchiectasis (Morandi et al., 1995).

Other

Dystrophic fingernails can be seen in an autosomally inherited disorder in association with rudimentary patellae, dysplastic elbows and anterior iliac horns, and a renal disease affecting some of the glomeruli (Perkoff, 1967).

Ridging of the fingernails and toenails and onychodystrophy may be manifestations of chronic graft versus host disease. If these or other integumentary signs (*vide supra*) are seen in a transplant recipient, look for other signs of this disease, especially in the mouth and conjunctiva (Bhushan and Collins, 2003).

Clubbing

Clubbing was described by Hippocrates in *Prognosis* 17: "The fingernails become curved and the fingers become warm, especially at their tips."

A Method

1. To detect clubbing, observe the angle between the nail bed and the base of the finger, the unguophalangeal angle (Lovibond angle). This is normally less than 180 degrees. Some clinicians have the patient place the right and left fingers against each other, knuckle to knuckle and fingernail tip to fingernail tip. If there is no abnormality of the angle, a definite rhombus will be seen between the distal phalanges. But if the unguophalangeal angle is greater than 180 degrees, no such rhombus will be seen (Schamroth, 1976). Try it on yourself. (The renowned electrocardiographer Leo Schamroth suggested this method after watching his own clubbing come and go during an episode of endocarditis.)
2. As a double check, one should see whether the nail "floats." The technique is a simple form of ballottement: Press the distal nail with a finger of one hand, while holding a finger of the other hand over the proximal nail. If the proximal nail rises easily through the spongy soft intervening tissue, the nails are said to "float."

It is essential to note the presence or absence of clubbing in the initial workup because many patients, especially black patients, have clubbing on a congenital basis. It is my distinct impression that such congenital clubbing (which obfuscates the use of this sign in signaling the presence of new disease) is not accompanied by a floating nail. However, I have not prospectively collected data on this point, nor have I seen the additional criterion of a floating nail sufficiently documented in the literature to give certainty to the similar claims of others on this point.

Can clubbing be identified reproducibly? Pyke had 12 physicians and 4 medical students examine 12 patients and state whether clubbing was present or not (Pyke, 1954). One finger was selected from each patient for examination, and unlabeled photographs of the same finger (front view and profile) were offered to the same panel. Only one physician was consistent in identifying the actual fingers and their photographs in exactly the same way. In only 2 of the 12 fingers was there any reliable consistency between examiners. Most of the finger-photograph pairings were described in a discordant manner by some examiners. That is, only the photograph was called clubbing or only the finger was called clubbing. But there was no clear trend toward misreading one more often than the other.

How should one interpret these results? I suggest that it is always possible to find someone who cannot do a particular task. Also, the clinically inept operate with no predefined criteria, whereas the clinically skilled arrive at the bedside with certain expectations. In Pyke's experiment, the examiners were required to produce at exit a written definition of the term "clubbing," although none knew beforehand that this would be asked of them. The 16 observers offered 14 different definitions!

Pyke's results should be contrasted with those of a later experiment, in which almost 100% agreement was achieved by 9 observers of 20 patients, who were evaluated for 20 stable physical signs (Smyllie et al., 1965). In fact, their agreement on clubbing was superior to the interobserver rating of tachypnea (which, as an externally counted event, would presumably be as objective as one could get).

Plaster casts of the fingers have been used to quantitate the ratio of the distal phalangeal depth (DPD) to the interphalangeal depth (IPD). The normal DPD/IPD averages 0.895 for the index finger, independent of age, sex, and race. A ratio of 1.0 exceeds the normal average by about 2.5 standard deviations. The DPD/IPD is greater than 1.0 in 85% of children with cystic fibrosis and in less than 5% of children with chronic asthma (Hansen-Flaschen and Nordberg, 1987). Calipers have been used to determine the DPD/IPD ratio in live fingers: the calipers should touch but not compress the tissue at the base of the nail and the distal interphalangeal joint of the index finger (Myers and Farquhar, 2001).

Conditions Associated with Clubbing

Clubbing may also be known by the misnomers of pulmonary osteodystrophy or osteoarthropathy—a misnomer because chronic pulmonary disease is not the only cause. Congenital heart disease is another cause that may involve chronic hemoglobin unsaturation. However, some of the diseases associated with clubbing are not accompanied by significant cyanosis (e.g., endocarditis, chronic renal disease, and severe ulcerative colitis). Finally, patients with Marie–Bamberger syndrome have clubbing of all extremities; thick, redundant skin (the so-called *pachydermoperiostosis* or *elephant skin*); and possibly the radiologic bone signs without any of the disease entities associated with clubbing.

Intrathoracic conditions associated with clubbing include neoplasms (bronchogenic carcinoma, mesothelioma, metastatic osteogenic sarcoma), suppurative disease (lung abscess, bronchiectasis, cystic fibrosis, empyema, chronic cavitary mycobacterial or fungal infections), diffuse pulmonary disease (idiopathic pulmonary fibrosis, asbestosis), cardiovascular disease (cyanotic congenital heart disease, infective endocarditis), gastrointestinal disease (inflammatory bowel disease, celiac disease), and hepatobiliary disease (particularly biliary and juvenile cirrhosis).

It is unusual for patients with chronic obstructive pulmonary disease to have a DPD/IPD greater than 1. Clubbing indicates an increased probability (likelihood ratio 3.9) of underlying lung cancer (Myers and Farquhar, 2001).

Development of clubbing over an 18-month period in a 45-year-old woman with adenocarcinoma of the lung was recently described; the clubbing and bone pain resolved after successful surgery (Faller and Atkinson, 2008).

For the Advanced Student. Unilateral clubbing is most commonly caused by aneurysm of the aorta or the innominate or subclavian artery. It has also been seen in recurrent subluxation of the shoulder, axillary tumor, Pancoast syndrome, unilateral erythromelalgia, and lymphangitis. Unilateral accentuation of clubbing has been seen in apical tuberculosis, empyema, ulnar neuritis, and brachial plexus neuroma (Mendlowitz, 1942).

Unidigital clubbing has been seen after trauma to the finger or the median nerve, in palmar arteriovenous fistulas, in sarcoid with felons, and with tophaceous gout (Mendlowitz, 1942). Symmetric but homolaterally unequal clubbing of the fingers is something I have observed in many black patients, as has Dr H. J. Roberts of Florida.

Nail-fold Capillaries

If one puts immersion oil on the nail fold, the nail-fold capillary loop may be visualized with the ophthalmoscope. However, to get meaningful information from the examination, I strongly advise using a dissecting microscope.

Two different types of abnormalities (Table 7.7) have been described (Kenik et al., 1981). The first, seen in scleroderma and dermatomyositis, consists of dilated segments, which have a "bushy" appearance. The second type has a convoluted, tortuous, "meandering" loop, which, in its most extreme form, reminds me of a cylindrical bunch of grapes. These abnormal nail folds may help make a specific diagnosis instead of "undifferentiated rheumatic disease" or "Raynaud phenomenon, unknown etiology."

Simply being able to distinguish abnormal from normal is also helpful, particularly when a history of the Raynaud phenomenon (see Chapter 18) is remote and ambiguous. (A challenge using a bucket of ice water may also serve as a helpful diagnostic maneuver.)

TABLE **7.7** *Abnormal nail-fold capillaries*

Diagnosis	Dilated and "bushy" (%)	Tortuous and meandering (%)
PSS	82–94	0(!)
Dermatomyositis	87	0(!)
SLE	3	42–75
MCTD	54	12
Raynaud disease	9	36
Normal	0	0

PSS, scleroderma (progressive systemic sclerosis); SLE, systemic lupus erythematosus; MCTD, mixed connective tissue disease.
From Kenik JG, Maricq HR, Bole GG. Blind evaluation of the diagnostic specificity of nailfold capillary microscopy in the connective tissue diseases. *Arthritis Rheum.* 1981;24:885–891, with permission.

Appendix 7.1

Answers to the Self-test in Fig. 7-1

There is another reason for the patient's posture. He wants to keep his legs dependent because of his peripheral vascular disease. He has probably been sitting up for much of the night and is fatigued. When lying down, he has one knee slightly flexed; flexion of the leg enhances blood flow (W.D. Jordan, *personal communication*, 1998). He has a midtarsal amputation of his left foot and a scar, possibly from a femoral–popliteal bypass, on his left leg. The scar might also be from a saphenous vein harvest for a coronary artery bypass graft; a sternotomy scar is not clearly visible, but you may be able to discern one with a magnifying glass. The swelling and hyperpigmentation of both the lower extremities suggest chronic venous stasis, which is not a feature of major arterial disease but is frequently seen in diabetics. Diabetic dermopathy, which produces small brown patches, is a consideration. The possibility of necrobiosis lipoidica diabeticorum has been raised but that is usually symmetrical. His tattoos suggest something about his socioeconomic background.

Appendix 7.2

Answers to the Question in Fig. 7-4

In Fig. 7-4, the name of the disease is derived from the name of the material that infiltrated the capillaries of the periorbital tissue: amyloidosis and amyloid, respectively.

Appendix 7.3

Answer to Self-test on Café Au Lait Spots in Neurofibromatosis

The sensitivity of the test ("more than five café au lait spots of diameter greater than 1.5 cm") is 75% and the specificity is 100%. In the general population (prevalence of disease = 1/3,500), the predictive value of a positive test is 100% and the predictive value of a negative test is 99.99%. (This is very slightly better than the 99.97% probability of a correct guess of "no disease" based on prevalence alone.) In the population of persons who have one affected parent, the prevalence of disease is 50%. Thus, of 1,000 persons, 500 will have no disease and a negative test, 375 will have disease and a positive test, and 125 will have disease and a negative test. The predictive value of a positive test is 100%, and the predictive value of a negative test is 80%.

Appendix 7.4

Answer to the Question in Fig. 7-6 and a Note on Terminology (Expressions of Ignorance)

In Fig. 7-6, only the word "mixed" is falsifiable. It refers to observable physical and immunologic characteristics of the cryoglobulin.

You should train yourself to be constantly self-conscious about what you are thinking. Asking whether a hypothesis is "falsifiable" (see Chapter 1) is a helpful device.

All the other words in the diagnosis given to that patient are cloaks for ignorance. "Cryptogenic," which means that the cause is hidden (as in a secret message or cryptogram), is a good word to use when one means to imply that a bright physician can decipher the clinical signs and symptoms and eventually discover the correct diagnosis. But when one means to say lost or permanently buried (like a body that is sealed in a crypt), a better word would be "agnogenic," which says that the cause is unknown (cf. "agnostic"). "Agnogenic" is a good, honest word if it comes at the end of a thoughtful, thorough evaluation but not if it comes before or in place of such an evaluation.

The term "essential" has been discussed in the section on blood pressure measurement in Chapter 6.

"Idiopathic" is related to "idiot," which comes from the Greek word *idios*, meaning self. It originated among the Greeks as a term of opprobrium for any person interested in himself to the total exclusion of his involvement in the common good. The word "idiot" thus carries no inherent connotation of imbecility or stupidity. An idioventricular rhythm is a rhythm generated by the ventricle itself (actually, a "smart" rhythm in cases of complete heart block, in which the alternative is no rhythm at all). The term "idiopathic" is really an oxymoron because it means literally that the thing causes itself. The student should avoid this mind-warping adjective and should substitute the phrase "of unknown cause." (Remember, half of medicine is knowing what you know and the other half is knowing what you do not know.)

These prefatory words should be sufficient to satisfy obscurantists, who can use them as pedantic preludes to any number of medical terms, thus disguising ignorance with vacuous euphony. However, there has recently been a new entry to the list, "spontaneous" bacterial peritonitis, which is apparently a bastard of spontaneous pneumothorax. With the latter, we know at least the exact instant of the onset of illness, and the hyperbole is justified to indicate that no etiology was known to its original describers, who thought the book of etiologies closed. However, considering the length to which Spallanzani went to prove to Bishop Needham that bacteria were not spontaneous (thus helping to prepare the way for the age of microbiology), it is especially ironic to apply this adjective to an infectious disease.

Appendix 7-5

Predictive Value of Skin Tags for the Presence of Colonic Polyps

Given that the prevalence of colonic polyps in an asymptomatic population over the age of 50 is 5% and that the sensitivity [TP/(TP + FN)] and specificity [TN/(TN + FP)] of skin tags as a test for polyps are both 0.75, a 2 × 2 table is constructed as follows for a population of 100:

TP = 3.75	FP = 23.75
FN = 1.25	TN = 71.25

Thus, the predictive value of a positive test = [TP/(TP + FP)] = 13.6%. The predictive value of a negative test = [TN/(FN +TN)] = 98.3%, *assuming that the patient is truly asymptomatic*.

A study in a primary care setting found the predictive value of a positive test to be 10.2% (Gould et al., 1988). In this study, the prevalence of colonic polyps was 8.7%. Please note that the predicted and observed predictive values of a positive test in unselected populations are so low as to make this a useless test in practice.

Although the predictive values of a negative test initially look appealing, this is not relevant to the issue of which patients should be further investigated. Stated another way, if the prevalence of polyps is 5%, then the prevalence of "no polyps" is 95%. A diagnosis of "no polyps" on every single patient would be right 95% of the time, and the absence of skin tags increases that percentage very slightly.

For the Guru. The likelihood ratio of having polyps if skin tags are absent is equal to (1−sensitivity)/specificity or 0.33 (see Chapter 1). Using the nomogram in Fig. 1-3, we see that this likelihood ratio converts a pretest probability of polyps of 5% into a posttest probability of less than 2%. Thus, the posttest probability of "no polyps" increases from 95% to about 98%. The likelihood ratio of having polyps if skin tags are present is equal to sensitivity/(1−sensitivity) or 3. Again using the nomogram, the posttest probability of polyps increases to about 13%, the predictive value of a positive test.

These facts would not have been apparent from the initial papers unless one made prevalence-dependent calculations, which showed the limits of the sign and turned out to be extremely close to what was finally found in practice.

Even in kindreds with familial colonic polyposis, skin tags do not predict the existence of colonic polyps (Luk, 1986). The presence of skin tags alone is not an indication for colonoscopy (Flegel et al., 1984).

Appendix 7.6

Koilonychia in a Well-Baby Clinic

The prevalence of disease is 94.6/400 or 23.65/100. The sensitivity is 19/94.6 or 20%, the specificity [TN/(TN + FP)] is 302.4/305.4 or 99%, and the predictive value of a positive test is 19/22 or 86%. The predictive value of a negative test is 302.4/(302.4 + 75.6) or 80%. The diagnostic accuracy = (302.4 + 19)/400 or 80.3%.

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CHAPTER

8

Lymph Nodes

It showed its first signs in men and women alike by means of swelling in the groin or under the armpits, some of which grew to the size of an apple or an egg, and these were called buboes.

—G. Boccaccio, *The Decameron*, Introduction

Points to Remember:

- Lymph nodes serve as sentinels of disease, as they do their job of defending the body against invaders or rogue cells (cancers). The search for lymph nodes is one of the most important parts of the physical examination, especially in patients with suspected infection or cancer.
- If you palpate carefully with proper technique, you will find many more nodes than others generally do.
- Along with precise location, determine the tenderness, size, consistency, and mobility of nodes.

The lymph nodes were discovered not by a physician but by a Swedish zoologist and botanist named Olof Rudbeck (1630–1702). They were confirmed by the Danish physician Bartholin, whose son discovered the glands known by that name (see Chapter 22).

The search for lymph nodes is easily one of the most important parts of the physical examination, especially in patients with a fever of unknown origin, weight loss, or known or suspected carcinoma. For example, on reviewing the oncology records in his practice, Dr David Clarkson of Alabama found that 21% of his cancer patients had measurable nodes.

Physicians must specifically look for lymph nodes using proper techniques; otherwise, they will miss them. In a study of the ability of primary care physicians to recognize physical findings associated with acquired immunodeficiency syndrome (AIDS), only 17% of 133 physicians detected diffuse lymphadenopathy in a patient complaining of fatigue, fever, and arthralgia (Paauw et al., 1995).

Dimensions

Although this chapter emphasizes the locations of lymph nodes and some techniques for finding them, there are four dimensions that must be described for any lymph node that is detected: (a) size, (b) tenderness, (c) consistency, and (d) matting. This is especially important for persons using this text, who will tend to find more lymph nodes than others do.

The clinical setting and the age of the patient are also important. Children are more likely than adults to respond with lymphoid hyperplasia to minor stimuli. In patients under age 30, lymphadenopathy is due to benign causes in 80% of cases. In patients over age 50, the cause of lymphadenopathy is benign in only 40% (Haynes, 1994) of cases.

1. As a general rule, lymph nodes bigger than the terminal phalanx of your little finger are significant. However, the benign chronic lymphadenopathy of intravenous drug users can occasionally cause larger nodes (Sapira, 1968), and a small node may be highly significant if it occurs in an unusual location (e.g., in the preauricular area). In cancer patients, the precise measurement of lymph nodes is an important index of response to treatment.

   Plastic calipers should be purchased for measuring nodes. They can also be used to measure other lumps, as in the breast.
2. Tenderness usually indicates inflammation. Tender nodes are usually of clinical importance.
3. Nodes that are stony hard are felt in metastatic neoplasia. Nodes that are not stony hard but very firm like the rubber of a pencil tip eraser are often due to Hodgkin disease or other lymphomas.

   The adjective "shotty" (not "shoddy") refers to small nodes that feel like buckshot under the skin. The size of the shot may be large, but all the nodes feel firm and disconnected (not matted) and are generally of the same size.
4. Matted nodes feel as if they are connected, and when one is moved, the others seem to move with it. Such nodes are found in metastatic neoplasms and sometimes in primary lymphatic malignancy. However, matting also occurs in nonneoplastic conditions such as chronic inflammation and occasional sarcoidosis.

Lymph Node Groups

Axillary Nodes

Normally, lymph nodes cannot be palpated in the axilla. However, with the following method, it is occasionally possible to find very small nodes, whose normality is indicated by their small size, lack of tenderness, and lack of matting (if multiple).

A Method

To examine the patient's left axilla, position your right hand so that your fingers are in the roof of the axilla and your palm is turned naturally toward the patient. With your other hand, passively abduct the patient's arm, advancing your examining fingers superiorly. Then, to relax the skin folds and give you the best opportunity to palpate the roof of the axilla, bring the patient's arm back down toward his side. Continue by pressing your fingers superiorly and medially. Next, work your fingertips down the medial wall of the axilla, trying to catch any lymph nodes in the fat pad and, lastly,

those beneath the fat pad and against the chest wall. Examine the other side in a mirror-image fashion.

Unilateral axillary adenopathy may be seen in infections of the upper extremity, breast cancer, cat-scratch disease, lymphoma, and brucellosis.

Epitrochlear Nodes

A Method

To feel the epitrochlear nodes at the patient's right epitrochlear area, grasp the patient's right hand with your right hand and place the palm of your left hand around the distal insertion of the triceps, as if you were a politician shaking hands (Fig. 8-1). The fingers of your left hand will now curl medially, pointing anteriorly (back at you). With your little finger on the medial epicondyle of the humerus, the remainder of your fingers should fall in or near a groove at the brachialis muscle. This is where the epitrochlear nodes will be if they are enlarged (or, *rarely*, normally palpable, as in a very thin person). Another reason for calling this a politician's handshake is that it is sometimes necessary to use your hand-grasping hand to pump the arm (extend and flex the elbow joint) 10 or 15 degrees so as to maximize the exposure of the subcutaneous anatomy to the palpating fingers. An incorrect method is shown in Fig. 8-2.

Reverse the procedure for examining the epitrochlear nodes on the other side.

In the absence of dermatitis or other inflammation of the hands or forearms, the presence of epitrochlear nodes is an extremely valuable clue to systemic diseases, such as sarcoid. Bilateral epitrochlear nodes are also seen in tularemia and secondary syphilis.

Teaching Hint

The best persons in whom to search for epitrochlear nodes are intravenous drug abusers. (Drug abuse is, of course, a systemic disease; patients may also have inflammation at injection sites.)

I was told that the type of handshake described above was invented by Sir William Osler when he was regius professor of medicine at Oxford. Supposedly, he would shake hands in this way with young men who came to call on his daughter, in order to search for epitrochlear nodes sometimes found in the systemic lymphadenopathy of syphilis. Additionally, from this position the palpating fingers can slip a short distance to feel for the bounding Corrigan pulse of luetic aortic insufficiency at the brachial artery.

Question: What is wrong with this story? (See Appendix 8.1 for the answer.)

Figure 8-1 Palpating for epitrochlear nodes. The examiner's right hand is shaking hands with the patient's right hand, while the examiner's left hand (shown) palpates correctly.

Figure 8-2 No matter how often Dr Vesalius dissects the arm, he will continue to miss the epitrochlear nodes unless he moves his hand higher and more posteriorly. See text and legend to Fig. 8-1 for the correct method for palpating for epitrochlear nodes. (From Medicine and the artist [*Ars medica*], with permission of the Philadelphia Museum of Art.)

Cervical Nodes

A Method for Posterior Cervical Nodes

1. Standing in front of the patient, put your fingers over the posterior cervical area and move quickly from top to bottom, searching for easily palpable nodes (Fig. 8-3). If you cannot see the nodes, this does not usually work.
2. Then, start again at the skull, putting your fingers in the groove behind the sternocleidomastoid and in front of the trapezius. Work your way down the groove, palpating deeply with almost a scratching motion. Once you have felt such lymph nodes in a patient, you will unconsciously adopt this type of motion from then on.

In the US at the present time, posterior cervical lymphadenopathy is very often due to dandruff (seborrheic dermatitis). It also occurs in scalp infections, toxoplasmosis, and rubella.

Anterior cervical nodes are found in front of the sternocleidomastoid. Search for them just after checking for submandibular nodes.

Figure 8-3 Sites of posterior cervical nodes are shown by stars. Arrow indicates the vertebra prominens (see Chapter 16). (Detail of Guilliano de Medici by Michelangelo.)

Other Nodes in the Head and Neck

1. The presence of a postauricular node, other than in an acute illness such as rubella, mandates a close look at the nasopharynx. Dr Alan Rapoport of Puerto Rico points out that what appears to be a postauricular node may be a tumor in the tail of the parotid gland.
2. Occipital nodes are commonly involved in the lymphadenopathy associated with AIDS. Together with postauricular nodes, they are typically involved in rubella.
3. The preauricular node may be enlarged in lymphoma or ipsilateral to conjunctivitis in Parinaud oculoglandular syndrome. This condition has been variously associated with Leptothrix infection, cat-scratch fever, viral epidemic conjunctivitis (Chapter 10), and American trypanosomiasis, following its inoculation at the outer canthus by the kissing (reduviid) bug. Once confined to rural Latin America, *Trypanosoma* cruzi is migrating north with population; the vector is found in many areas of the US (Bern et al., 2007). Preauricular adenopathy may also be a sign of chlamydial, herpetic, adenoviral, or gonococcal keratoconjunctivitis. A note on terminology: Parinaud syndrome (see Chapter 26) is also the name given to paralysis of conjugate vertical gaze, especially the upward gaze, which results from damage in the region of the posterior commissures, a hallmark of pinealoma.
4. There are nodes in the hypothyroid membrane that are normally not palpable. These nodes may become enlarged and palpable in tracheal carcinoma, in carcinoma of the thyroid, in de Quervain thyroiditis, or in Hashimoto thyroiditis. In association with carcinoma, they are called *Delphian nodes*, in honor of the Greek oracle that would foretell disaster to those clever enough to correctly interpret its usually cryptic messages.
5. The submandibular nodes are arranged along the underside of the mandibles in a zone extending a few centimeters from the midline. The best way to learn to feel the submandibular nodes is to find a patient with infected teeth. The submandibular nodes under the chin have their own adjective, submental. Bimanual palpation may be useful for detecting mandibular and submental nodes, according to Adams (1958). Intra-abdominal malignancies do not metastasize to submental nodes. If submental nodes are present when there is no dental pathology, one would do better to diagnose an independent lymphoma, even in the presence of known intra-abdominal neoplasia.

Supraclavicular Nodes

A Method

1. When searching for lymph nodes in the supraclavicular fossa, have the patient sit up.
2. It is a good idea to have the patient perform the Valsalva maneuver (Kuiper and Papp, 1969), which occasionally brings out an otherwise inapparent node.
3. Wiener and Nathanson (see Chapter 29) point out that one should always palpate for supraclavicular nodes with the patient's head looking straight ahead and the arms down so as to keep from "finding" cervical vertebrae or the omohyoid muscle, either of which might be incorrectly identified as a node.

In addition to the usual systemic diseases that cause lymphadenopathy, cancer of the breast and bronchus may metastasize to the ipsilateral supraclavicular nodes. But the left supraclavicular nodes may additionally be involved by metastases from the abdominal organs. In that case, even a single lymph node may herald an intra-abdominal carcinoma, and so it is called a *sentinel node*. (This is the same thing as Troisier node or Virchow node.) While gastric carcinoma is the usual cause, the primary carcinoma may be as far away as the testis.

Sentinel nodes may rarely appear in the retrosternal notch.

Inguinal and Femoral Nodes

The locations of these two groups of lymph nodes (Table 8.1) are shown in Fig. 8-4. When enlarged, they can be seen in a thin patient. Even in an obese patient, they are easily palpable when enlarged; no specific method is required. Inguinal nodes from 0.5 to 2.0 cm may be palpable in the normal adult (Haynes, 1994).

This text makes the distinction between the femoral and inguinal nodes because an old chestnut taught that the former, but not the latter, would become enlarged in cases of pedal dermatophytoses and other nonspecific inflammations involving the nodes secondarily. While this hypothesis, elegant in its simplicity, has never to my knowledge been tested, it seems to work. The converse would state

TABLE **8.1** *A concordance of nomenclature for lymph nodes in the groin*

Location	Goss (1966)	Wapnick et al. (1973)	This text
Above the inguinal ligament	(None!)	(None!)	Inguinal nodes, superior
Just below the inguinal ligament and horizontal	Superficial inguinal	Horizontal femoral	Inguinal nodes, inferior
Superficial vertically grouped nodes	Superficial subinguinal nodes	Vertical femoral nodes (?)	Femoral nodes
Deep vertically grouped nodes including node of Cloquet	Deep subinguinal nodes	Vertical femoral nodes	Femoral nodes

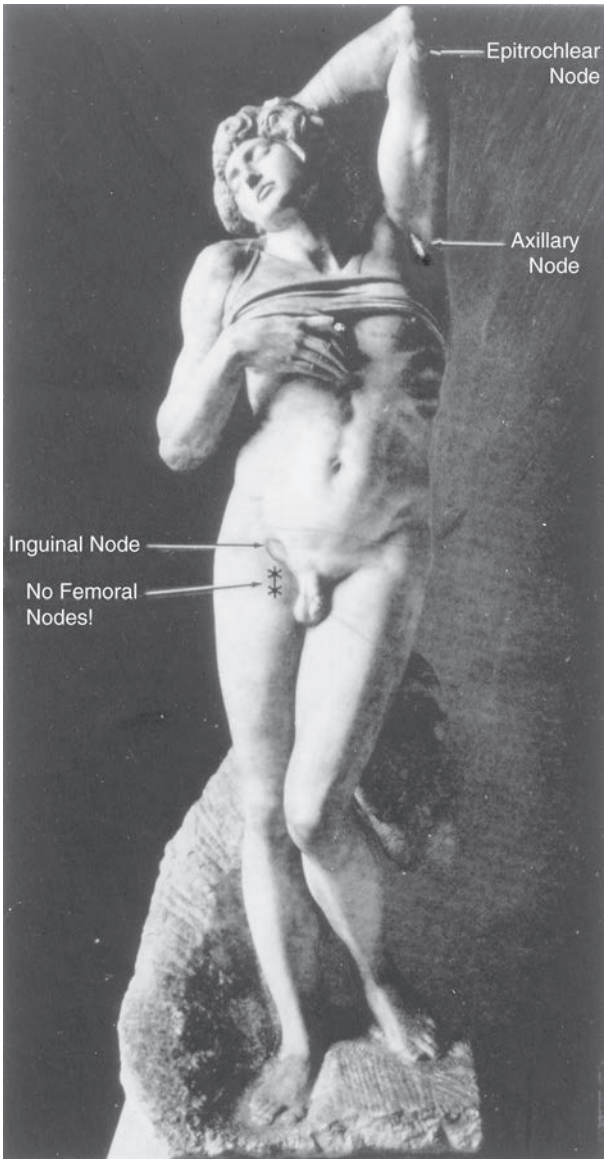

FIGURE 8-4 Axillary and inguinal nodes are present, but there are no femoral nodes visible. (Monument of Pope Julius II by Michelangelo: The dying slave.)

that inguinal nodes are highly predictive of genital or pelvic disease or, depending on the other findings of the case, a systemic disease. In fact, it is my distinct impression that inguinal nodes meeting the criteria for significance implicit in the four dimensions tend to produce biopsy material helpful in the evaluation of the patient. But femoral nodes, especially if they do not meet the criteria, tend to be interpreted histologically as "reactive hyperplasia."

While the "hedge" has been called the national flower of pathologists, the problem with "reactive hyperplasia" may result from the tendency of the surgeon to choose the node that is most easily accessible, rather than the one that is most deviant according to the four dimensions.

In massive inguinal lymphadenopathy, there may be a groove running between the nodes. This occurs because the fold of the groin is not obliterated between the superior and inferior inguinal nodes. According to Bailey (Clain, 1973), this groove is pathognomonic for lymphogranuloma venereum.

I have also seen this groove in a case of squamous carcinoma of the skin with metastases to the two sets of lymph nodes. This teaches us that most of the findings in medicine that are well-known for being diagnostic of a disease are in fact not so diagnostic. (Conversely, most of the signs that are diagnostic are not well-known.)

For the Attending. It has been suggested (Desprez-Curley, 1979) that biopsy of the inguinal and femoral nodes may now be delayed until attempts to reach a diagnosis by other means (such as lymphangiography or cytologic examination of aspirates) fail. Further improvements in diagnostic techniques as well as the increasing influence of the legal and economic professions will probably further change the workup of a palpable lymph node. The point to be made to students is that if you cannot find the nodes, you cannot do any type of workup.

A word on nomenclature is in order. I have divided the lymph nodes into two groups according to the way in which I was taught. Please note the absence of uniformity among systems of nomenclature (Table 8.1). Gray's system has no nodes called "femoral," and one contemporary system has none called "inguinal." Neither system recognizes nodes above the inguinal ligament, without which Bailey groove (*vide supra*) could not exist.

Popliteal Nodes

I do not routinely check for popliteal nodes. The current teaching is that lesions on the heel drain to the popliteal nodes before they drain to those in the groin (*vide infra*). Presumably, this information would somehow let one distinguish an anterior foot problem from a posterior foot problem (a distinction presumably feasible on other grounds), or it might help in staging lesions of the heel. However, a lymphangiographic study (Riveros and Cabanas, 1972) of normals and persons with lesions of the heel supports my disinterest. Popliteal lymph nodes may be impalpable because the examiner is inept, because they are so deep, because they are not involved, or because they do not exist in a given patient. Furthermore, the invasion of popliteal nodes may either precede or follow the involvement of other groups. The various possibilities cannot be resolved without lymphangiography.

The lesson is that the physical examination must not be stretched beyond its limits.

Paraumbilical Nodes (Sister Joseph Node)

Patients with intra-abdominal or pelvic neoplasms may have metastases to a paraumbilical node that is easily palpable through the navel. This node is named after Sister Joseph, the superintendent at St Mary's Hospital, a unit of the early Mayo Clinic (Schwartz, 1987). According to the legend, she became proficient at predicting the results of the celiotomy on the basis of the presence of this node, which she felt while hand-prepping the abdomen. This node is often called, incorrectly, "Sister Mary Joseph's nodule," perhaps because Catholic nuns have traditionally taken the name of Mary in addition to another name.

Evaluating the Clinical Significance of Lymph Nodes

In observing master clinicians, I have noticed that they do three things that the jejune do not. First, they describe the nodes according to the four dimensions. In the case of obvious deviations from the normal, they immediately promote the lymphadenopathy to the top of the list of findings that must be explained. Second, they evaluate the lymph nodes within the context of the total set of clinical findings. Junior students tend to forget this principle in the rush of clinical duties. (They might want to read about diagnostic strategies in Chapter 27 before doing the assessment of a patient with lymphadenopathy.) Third, they distinguish between local and generalized lymphadenopathies (involving more than two separate anatomic regions), which have a separate differential diagnosis. Some of the causes of local adenopathy have been mentioned above or are discussed in the chapters pertaining to the specific region. Some causes of generalized lymphadenopathy are listed in Table 8.2.

TABLE **8.2** *Some causes of generalized lymphadenopathy*

Infectious causes
- Scarlet fever
- Rheumatic fever
- Brucellosis
- Secondary syphilis
- Rubella
- Tularemia
- Bubonic plague
- Infectious mononucleosis
- Tuberculosis
- Cat-scratch fever
- Measles
- Toxoplasmosis
- Sporotrichosis
- African sleeping sickness
- Chagas disease
- Kala azar
- AIDS
- AIDS-related complex
- Metabolic diseases
- Gaucher disease
- Niemann–Pick disease
- Hyperthyroidism

Neoplastic causes
- Lymphatic leukemia
- Hodgkin disease
- Other lymphoreticular malignancies

Collagen-vascular diseases
- Still disease
- Rheumatoid arthritis
- Systemic lupus erythematosus
- Dermatomyositis

Miscellaneous causes
- Phenytoin ingestion
- Amyloidosis
- Serum sickness
- Sarcoidosis
- Scabies infestation
- Intravenous drug abuse

Appendix 8.1

What is Wrong with the Story about Osler?

First, epitrochlear nodes are neither completely sensitive nor pathognomonic for secondary syphilis. Second, Corrigan pulse is neither completely sensitive nor pathognomonic for aortic insufficiency, whether of luetic or other etiology. Third, this method cannot detect all of the infectious forms of syphilis. Fourth, would Osler have palpated through a jacket? Finally, Osler and his wife never had a daughter.

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CHAPTER 9

The Head

Men's heads are by no means all like to one another, nor are the sutures of the head of all men constructed in the same form.
—*Hippocratic Writings*

Points to Remember:

- Head trauma should never be assumed to be "minor," especially in infants. Signs may be delayed.
- Facial features may suggest the diagnosis in many congenital, endocrine, autoimmune, or other systemic diseases.

Inspection

Self-study

Before reading this chapter, inspect the first eight illustrations without reading the legends. For each, commit to writing (a) what you see and (b) a diagnosis (if you can).

Trauma

In cases of trauma or coma of unknown cause, examination of the skull is especially important. Look for bruises, swellings, and cerebrospinal fluid otorrhea or rhinorrhea (see Chapter 12).

Signs of blunt head trauma in an infant may be subtle. Dermatographic imprints of the striking object may be made visible only on postmortem skin blanching (Elner et al., 1990). More than half of the scalp contusions and skull fractures found at autopsy were missed on the initial physical examination in a series of 48 cases of the so-called *shaken baby syndrome* (see Chapters 10 and 26). (Some prefer the term "shaking impact syndrome" [Graham, 2001] because of evidence that shaking alone cannot generate sufficient force [Duhaime et al., 1987].) It is also possible that an impact may not leave any external signs, if the fall or blow is cushioned by a load-distributing material, because the infant skull is easily deformed (Ommaya et al., 2002).

A bruise over the mastoid (Fig. 9-1A) signifies a middle fossa basal skull fracture. This is called the *Battle sign*, although it was first noted by Sir Prescott Hewett. The Battle sign tends to be on the same side as the fracture, although a fracture on the opposite side or bilateral fractures can cause the sign. It usually occurs within the first 48 hours after injury, although it can be delayed for 3 to 12 days. The predictive value of a positive test is essentially 100% (Alter et al., 1974). Standard computerized tomographic (CT) scans may not demonstrate the fracture line. Coronal images or "fine cut" CT scans will show the fracture at least 50% of the time (M. Schlitt, *personal communication*, 1998).

False negatives were noted by Battle, who stated that "it is necessary for the production of this sign that there should be a complete fracture, one penetrating both tables" (Battle, 1890).

Battle also discussed apparent false positives due to external trauma to the mastoid. These were invariably accompanied by ecchymosis over the parietal area and the external ear.

Battle's paper was actually a compendium of signs of basal skull fracture, including anterior basal skull fracture (presenting with conjunctival and eyelid hemorrhage, epistaxis from one nostril, unilateral proptosis [Chapter 10], unilateral conjunctival chemosis [Chapter 10], or cranial nerve dysfunction) and what Battle called "optic neuritis" but what would today probably be called *papilledema* (see Chapter 10).

Raccoon eyes (Fig. 9-1B) could come from external trauma with no skull fracture, from a skull fracture, or from orbital bleeding. Thus, the raccoon eyes are of less diagnostic value than the Battle sign.

Raccoon eyes should be distinguished from amyloid eyes (see Chapter 7).

Periorbital hemorrhages and scalp bruising have been reported in a child with head trauma as an unusual manifestation of scurvy, not accompanied by typical clinical findings but responding dramatically to vitamin C (Ahuja and Karande, 2002).

Because head injury is frequently associated with cervical spine injury, the presence of any of these signs reinforces the importance of protecting the cervical spine until injury to that region can be ruled out.

Head trauma should be taken seriously, even in the absence of these dramatic signs. Children have died or suffered serious head injury in witnessed falls from a height of as little as 2 ft (Plunkett, 2001). The mode of injury in 26 cases of acute infantile subdural hematoma included falls onto a Japanese mat while sitting or standing (Aoki and Masuzawa, 1984). A study in infant cadavers showed that free fall from a height of 82 cm can produce skull fractures (Weber, 1984), even if the fall is onto a softly cushioned surface (Weber, 1985). Until late infancy, there are areas of susceptibility especially to fractures in the parietal bone and elsewhere (Weber, 1987). Deterioration can occur after a lucid interval. Be sure to examine the fundi (see Chapter 10) and check the pupils carefully.

A history of head trauma, even if remote, may be pertinent, as symptoms may be long delayed. Rapid acceleration/deceleration may cause a pressure wave of sufficient magnitude to damage the organ of Corti or cause hemorrhage into the labyrinth, resulting in hydrops. The outcome could be symptoms of Meniere disease, even years later (DiBiase and Arriaga, 1997).

The neurologic assessment of patients with head trauma is covered in Chapter 26.

A B

FIGURE 9-1 **A:** Battle sign. **B:** Raccoon eyes. This gentleman returned home late one night after a symposium, only to awaken the next morning amnesic for the events of the evening and be unable to recognize his wife. The further discovery that his wallet was missing suggested that he had been set upon by villains, a suspicion that was heightened with the appearance of these skin signs. The herpetic outbreak (which is bilateral) was posttraumatic. Additionally, there was blood behind the left tympanic membrane (ipsilateral to Battle sign) and left papilledema, presumably because of hemorrhage down the optic nerve sheath. The initial CAT scan revealed bifrontal intracerebral hemorrhages and a right temporal hemorrhage but missed his basal skull fracture, which was later seen on a repeat skull film taken after the Battle sign was recognized.

A Comment on Contemporary Terminology

These days, when the head is described at all, it is usually called "normocephalic." (Actually, the head is "normal." It is the patient who is normocephalic!) However, if everyone is "normocephalic," it seems superfluous to say so. Note that normocephaly, like having ten fingers, is 100% sensitive for almost all diseases (see Chapter 1). However, not quite everyone is normocephalic, at least if a careful examination of the head is actually done.

"Normocephalic" was previously used as a descriptor that meant that the patient was not brachycephalic or dolichocephalic, anthropologic terms defined by specific measurements of the cranial dimensions, previously thought to be of diagnostic value. Such distortions in the shape of the skull of infants are caused by the premature union of one or more cranial sutures.

Later, "normocephalic" was used to mean that the skull did not have burr holes or frontal bossing. (Burr holes were formerly placed as a diagnostic for subdural hematomas, a procedure made obsolete by the computerized axial tomographic [CAT] scan.)

Frontal bossing, or an unusually prominent forehead, is a sign of congenital heart disease, syphilis, rickets, or, most commonly, hydrocephalus (Fig. 9-2). In the elderly, it may signify Paget disease. Unfortunately, such diagnostically useful bumps have been thrown out with the bath water of phrenology.

Microcephaly (Fig. 9-3) can be a familial trait or a part of the congenital TORCH syndrome (due to toxoplasmosis, rubella, cytomegalovirus, or herpes).

Flattening of the back of the skull is caused by prolonged recumbency; this usually disappears spontaneously once the child is able to sit.

Marked cranial and facial asymmetry may be caused by neurofibromatosis.

In infants and children, head circumference should be measured and plotted on a head circumference/growth graph to check for developing hydrocephalus.

A Historic Interlude

The story of phrenology reminds us that a scientific proposition is not validated by being the focus of prestigious journals or professional societies; becoming part of "professionally accepted standards of care"; gaining acceptance by political authorities, influential scientists, or the vast majority of the populace; or being denounced by the Roman Catholic Church. Phrenology gained such a degree of popularity that in 1832, there were 29 phrenologic societies in

FIGURE 9-2 A patient with frontal bossing due to hydrocephalus since early childhood. (Courtesy of Dr Michael Schlitt of Washington, with permission.)

Figure 9-3 Microcephaly. The face is of normal size, but the head is small with a sloping forehead. The scalp is redundant and furrowed.

Great Britain and several journals devoted to phrenology in Great Britain and America, including one (the *Phrenological Journal*) that went through 20 volumes (*Encyclopaedia Britannica*, 1911). It is said that Clara Barton entered nursing on the advice of her phrenologist and that General McClellan recruited spies for the Union Army on the basis of the phrenologic profiles, insisting on a prominent secretiveness faculty. Horace Greeley, editor of the *New York Tribune*, thought that accidents could be reduced if railroad engineers were selected based on the shapes of their heads. Presidents James Garfield and John Tyler both had their heads examined.

President Ulysses S. Grant met so often with his phrenologist that Democrats charged that the doctor was dictating domestic policy. In the south of France, the idea was carried to its logical conclusion by binding the heads of young children with tight bandages to squeeze their brains into a desirable shape. The Roman Catholic Church banned phrenology in Austria because the Vatican considered it a heresy. There is, however, an interesting anecdotal finding: the skull of Austrian anatomist Franz Joseph Gall, who introduced the theory of phrenology, was found to be twice as thick as normal at autopsy (Scott, 1998).

However, phrenology was a scientific proposition in that it was falsifiable and has indeed been falsified.

Movements of the Head

The bobbing of the head fore and aft during systole is called the *de Musset sign* (see Chapter 17). It may be seen in aortic insufficiency or any other high stroke volume condition. Lateral systolic head bobbing is a sign of severe tricuspid regurgitation or right ventricular dysfunction (see Chapter 19).

Dyskinetic movements or dystonic posturing of the head is seen in primary neurologic diseases and in both the dystonias and the tardive dyskinesia associated with dopaminergic blockers such as the phenothiazines (see Chapter 26).

Torticollis is discussed in Chapters 25 and 26.

Facies

A Pedagogic Note

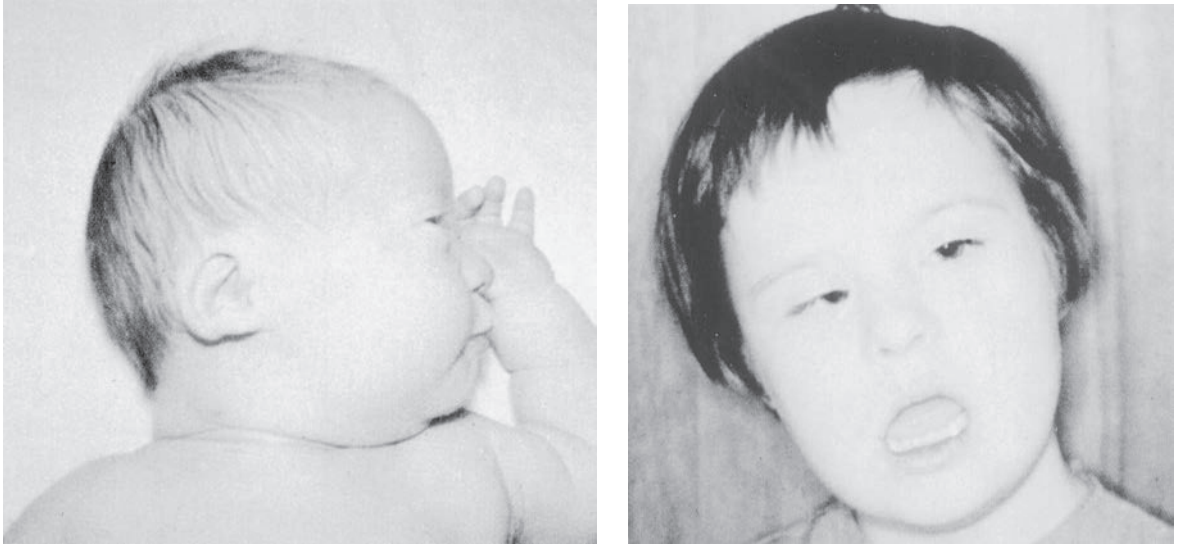
The appearance of the face is quite characteristic in a number of congenital disorders and systemic illnesses. Only a few examples can be presented here.

Down Syndrome

Probably, the most frequently seen of the stereotypic facies is that of Down syndrome, shown in Fig. 9-4. The tongue tends to protrude, and the whole face appears flat and round. The appearance is diagnostic.

Scleroderma

Patients with scleroderma (progressive systemic sclerosis or PSS) have a pinched nose, a mouth that will not open far (see Chapter 13),



A B

Figure 9-4 Down syndrome. **A:** An infant who has a flattened face; malformed ears with a small lobule; and a short, broad neck with excessive, loose skin over the nape. **B:** An older child with the stereotypic facies: open mouth, protruding tongue, epicanthal folds, strabismus (see Chapter 10), and small nose with a broad bridge. (From Gellis SS, Feingold M. *Atlas of Mental Retardation Syndromes: Visual Diagnosis of Facies and Physical Findings*. U.S. Department of Health, Education, and Welfare; 1968, with permission.)

Figure 9-5 The classic facies of myxedema. (Courtesy of Dr Chris Casten and *Consultant*, the Cliggott Publishing Group of CMP Healthcare Media, Darien, CT, with permission.)

and shiny, tight skin. The usual wrinkles of time can become obliterated, but because of the pinched nose, women so affected still do not look younger than their age.

Morphea or localized scleroderma (to be distinguished from PSS) may present with a vertical patch or scar over the skull. This "dueling scar" looks like a healed saber blow or *coup de sabre*.

Endocrine Disorders

Myxedema

The patient shown in Fig. 9-5 has myxedema (primary hypothyroidism). In addition to the coarse hair and dry rough skin (see Chapter 7), there is a puffy appearance and a yellow hue (from increased carotene). The nephrotic syndrome has a similar appearance in which the puffiness results from hypoproteinemic edema and the yellow hue from urochromes.

Cushing Syndrome

Obese persons with diabetes and hypertension are frequently suspected of having Cushing syndrome, although the vast majority of them do not. Buccal fat pads and moon facies are considered to be reliable signs of Cushing syndrome. To check for buccal fat pads, stand directly in front of the patient and try to see his ears. Facial fat sufficient to obscure normal ears is a positive sign (although the patient still may not have Cushing's). Protuberant ears can be the cause of a false negative. The specificity of this test is still high because most patients who do not have this sign will also not have the disease. This reemphasizes the importance of the prevalence of disease and shows why specificity is a less-useful concept than predictive value.

For the Attending. You are probably safe in "ruling out" Cushing syndrome on the basis of any physical finding that you wish to offer because it is so rare. When betting, always bet that the patient does not have Cushing's. It is such a rare disease that you will usually be correct. But in all fairness to students, you should point out that you are playing the prevalence game.

Acromegaly

Increasing hat size, prognathism with wider spacing of the teeth, and coarsening of the features are signs of acromegaly, as bone and soft tissue increase in bulk (Fig. 9-6). Enlargement of the sinuses may result in a hollow-sounding voice. Serial photographs may

A B

Figure 9-6 **A:** Typical facies of acromegaly. The features are coarse because the cartilages of the nose, and possibly eyelids and ears, are enlarged and thickened. The lower lip is thick and projecting. The bones of the lower jaw are enlarged to such an extent that prognathism is present. The supraorbital ridges are prominent, so the rest of the forehead seems to retreat, while the skin of the forehead is hypertrophied and thrown into folds. (From Osborne OT. Acromegaly. In: Buck AH, ed. *A Reference Handbook of the Medical Sciences*. Vol. 1. New York: William Wood and Company; 1900:86–97, with permission.) **B:** Skull of an acromegalic, showing prognathism and prominent supraorbital ridges.

suggest the diagnosis. An excellent example is Richard Kiel, the actor who plays "Jaws" in the 1977 James Bond movie, *The Spy Who Loved Me*, with Roger Moore and Barbara Bach (M. Schlitt, *personal communication*, 1998).

Congenital Syphilis

The facies of congenital syphilis, including Hutchinson teeth, is described in this case report (Hutchinson, 1859):

> Henry C., aged 14, admitted on account of the remains of chronic keratitis in both eyes. All congestion had long since disappeared and only dim white interstitial clouds of opacity remained. The bridge of his nose was broad and rather flat; teeth most characteristic, being notched and tuberculated. There were wide spaces between the incisors, and all the four canines showed a central tubercle. (The nose is better described in Chapter 12—see Fig. 12-2; the teeth in Chapter 13—see Fig. 13-4.)

Brueghel Syndrome

Brueghel syndrome is unique among eponymic neurologic disorders in being named not for the neurologist who described it but for the artist thought to have painted its image (Fig. 9-7). This oromandibular dystonia, involving the motor branch of the trigeminal nerve, produces a gaping mouth (Gilbert, 1996). This syndrome could actually be a focal manifestation of the syndrome of adult-onset torsion dystonia (Marsden, 1976). Brueghel syndrome has been confused with Meige syndrome, a disorder of the facial nerve or extrapyramidal system, in which the essential feature is blepharospasm, possibly combined with spasms of the middle and lower facial or oromandibular muscles.

Figure 9-7 Photograph of "The Gaper" by Brueghel, the Elder. (Courtesy of the Musées Royaux des Beaux-Arts, Brussels.) This man may actually demonstrate a physiologic dystonia called *yawning*; the partial closure of the eyelids and retraction of the upper lip are characteristic.

Smoker's Face

About half the people who have smoked cigarettes for 10 years or more will have a characteristic facial appearance. The features appear gaunt, and the skin is wrinkled, atrophic, and gray. The complexion may be plethoric, with a slightly orange, red, or purple cast. Age, exposure to sun, and recent weight change failed to account for the differences between the smoking and the control groups (Soffer, 1986).

Hippocratic Facies

Hippocrates described the facies of a patient dying after an exhausting illness as follows: "the nose sharp, the eyes sunken, the temples fallen in, the ears cold and drawn in and their lobes distorted, the skin of the face hard, stretched, and dry, and the color of the face pale or dusky" (Lloyd, 1978) (Fig. 9-8).

Facial Expression

Observe the face while checking for pain during the physical examination, especially when evaluating a patient with abdominal pain.

Of course, the facial expression can also give important clues to emotional states (see Chapter 26).

An expressionless or masklike face is characteristic of Parkinson disease.

Rash

Rashes that involve the face are generally described under the examination of the skin. There is one rash that may occur only on the face that is of particular diagnostic importance, the malar rash of systemic lupus erythematosus (SLE).

The malar rash is one of the 11 criteria of the American Rheumatism Association for the diagnosis of SLE (see Table 24.3).

The malar rash needs to be distinguished from the malar flush, which may be seen in mitral stenosis or pulmonic stenosis (Fig. 9-9A; see also Chapter 17).

Tuberculosis involving the malar area is called *lupus vulgaris* (Fig. 9-9B).

Patients with the chronic metastatic ileal (classic) carcinoid syndrome may have a vascular, violaceous malar rash.

A Note on the Case Record

When one of the above diagnostic facies is recognized, it is often moved into the "general appearance" section of the case record. Similarly, if the face suggests a certain affective disorder, then the information is usually moved from the "head" section and inserted into the "mental status" section. (Other examples of "highlighting" the findings by moving them out of their customary portion of the case record are discussed in Chapter 4.) The important teaching point is that when the examiner fails to present negative findings in their proper topologic place, they are soon dropped from his routine and are later missed even when positive.

A B

FIGURE 9-8 **A:** Madonna Doni by Michelangelo, c. 1504. Joseph shows features of the Hippocratic facies, especially temporal wasting. The infant Jesus is nearly normocephalic. Michelangelo was the first to portray infants as infants (with proportionately larger heads), rather than as small adults. It took more than 200 years for his influence to prevail, in a guilded age without fax machines; Goya (1746–1828) was still painting little adults. The lesson for medical students: Even great artists may see what they expect to see or record what convention dictates or what the master of their school has taught. Scientists and physicians must always seek truth and record faithfully what they find, regardless of "guidelines" promulgated by "expert" committees. (From Goldscheider L. *Michelangelo: Paintings, Sculptures, and Architecture.* London: Phaidon Press; 1962, with permission.) **B:** Photograph of a normal infant for comparison. (Courtesy of Helen Winski.)

Palpation

Palpation of the skull is most important in the examination of the infant, which is beyond the scope of this text. In the adult, the fontanelles have closed, and the major purpose of skull palpation is to find unexplained lumps in the scalp. Having never found one (not previously reported by the patient) that was not either a wen or lipoma, I have dropped this procedure from my *routine* examination. (Some may object to dropping parts of the routine, on the basis that "if two generations stop it, it becomes lost.")

Palpable crepitus is found in association with skull rarefaction diseases, such as syphilis, infantile rickets, and hydrocephalus (*French's Index of Differential Diagnosis* [Hart, 1985]).

Formerly, we palpated all skulls for burr holes to see whether the patient had ever been investigated for subdural hematomas, especially if the patient was comatose or suspected of having Munchausen syndrome (see Chapter 2). Palpation may also show a defect due to a craniotomy.

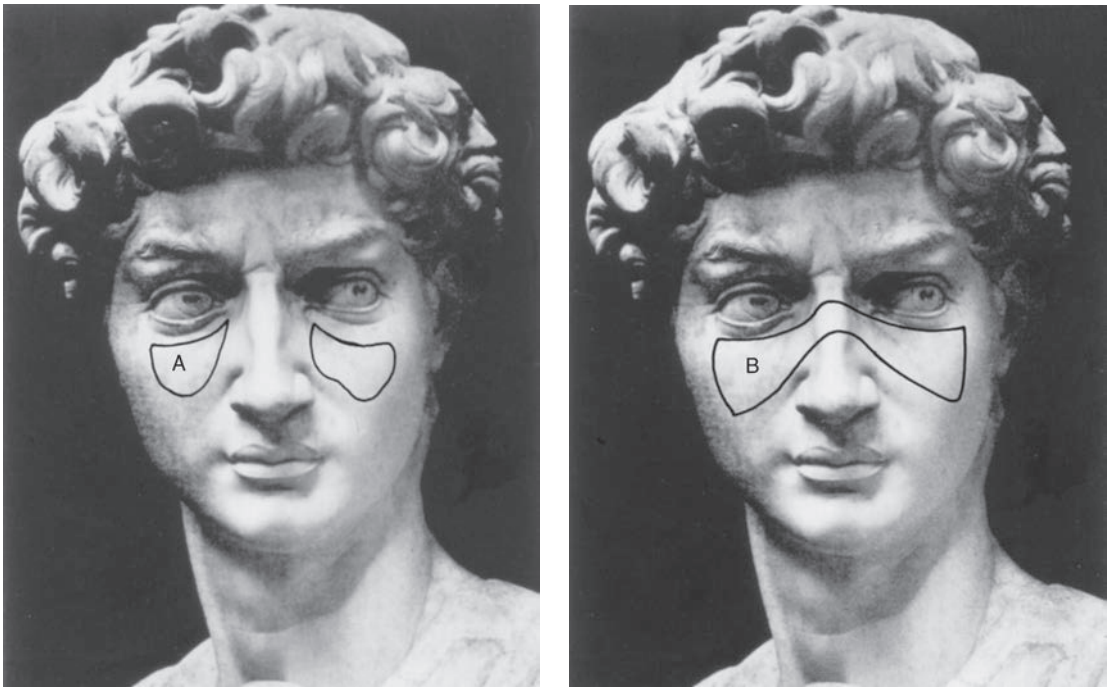
Palpation of the occiput is frequently uncomfortable for patients with posterior fossa tumors and thus should be done on anyone complaining of vertigo, dizziness, or unilateral hearing loss. (Do not forget to check the hearing; see Chapter 11 and Fig. 11-4.) A positive result, coupled with other findings, might suggest that a CT scan or magnetic resonance imaging (MRI) is in order (M. Schlitt, *personal communication*, 1998).

The areas over the maxillary and frontal sinuses may be tender if the sinuses are infected. These are the only sinuses accessible to direct palpation. This finding is neither very sensitive nor specific. Sensitivity is about 50% and specificity between 62% and 65% (Williams and Simel, 1993).

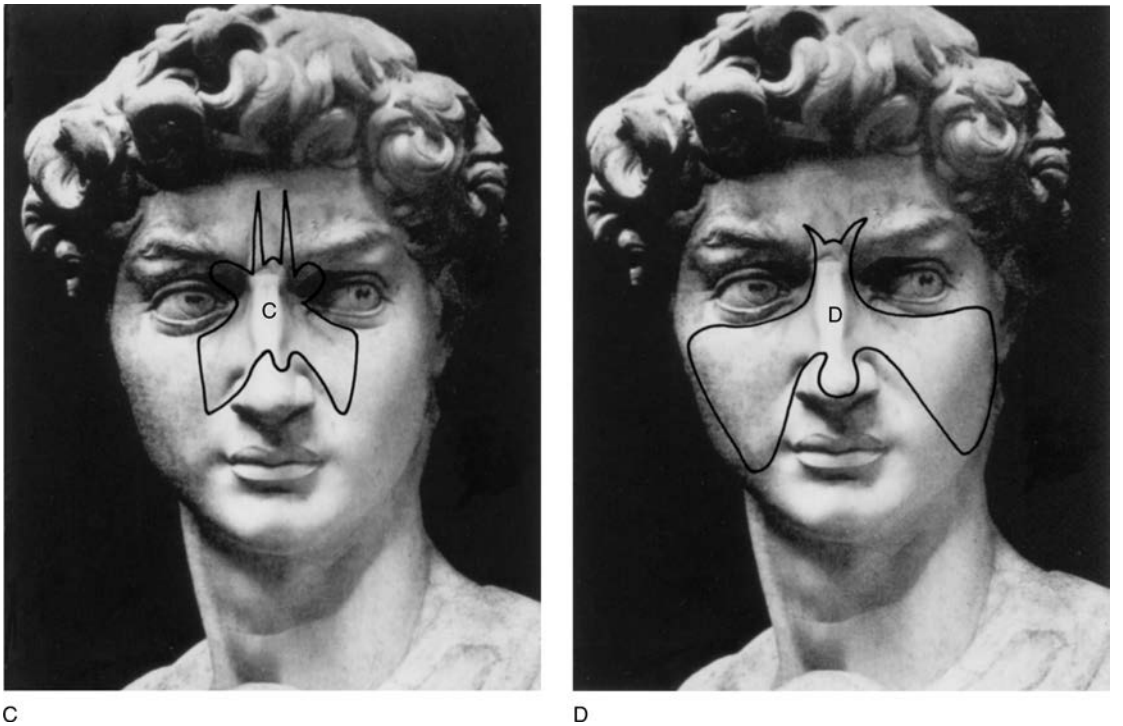
The mastoid may be tender to palpation in postauricular lymphadenitis, otitis media, and acute (but not chronic) mastoiditis. The lymphadenitis may be diagnosed simply by finding the involved node, leaving only the other two to be differentiated, as follows.

Just above the auditory meatus, the temporal bone contains a recess shaped like a quarter moon (dark side down). This is called the *suprameatal triangle of Macewen*. Try feeling this on your own temporal bones right above the insertion of the external ear. The recess is a little posterior to the uppermost part of the external ear insertion, at 1 o'clock on the left and 11 o'clock on the right. This area is tender in mastoiditis, but not in otitis media, assuming that you have not disturbed the external ear while performing the test. The posterior aspect of the junction of the external ear and the mastoid forms an angle that is obliterated in some cases of mastoiditis, but never in external otitis, even if complicated. Postauricular edema and erythema occur in 76% and 65%, respectively, of children with mastoiditis (Gliklich et al., 1996).

For the Very Advanced Student. Mastoiditis in the presence of a sixth cranial nerve palsy is called *Gradenigo syndrome* (also see Chapter 11). There may also be pain in the distribution of the ophthalmic branch of the fifth cranial nerve. Rarely, mastoiditis may be associated with an ipsilateral seventh nerve palsy with sparing of the sixth. These are not seen in adequately treated cases of petrositis, mastoiditis,



A B



C D

Figure 9-9 **A:** Malar flush. Note the erythema (not a scaling rash) that does not cross the bridge of the nose. **B:** The malar or "wolf" rash. (This is a scaling rash, not just an erythema.) "Wolf" is English for "lupus." In some parts of the world, the most common cause of the lupus rash is lupus vulgaris, which is due to tuberculosis. But in the US, SLE is more "vulgaris" (common) than facial tuberculosis. Note that the rash crosses the bridge of the nose (in this case) but does not extend above the eyebrows. (Dr René Wegria of Missouri had considerable experience with lupus vulgaris. It was the custom to make the diagnosis by placing a glass slide against the lesion and exerting downward pressure on the lesion. When viewed through a slide thus held, lupus vulgaris had the appearance of cooked kernels of corn.) **C:** A true, butterfly rash of SLE, sketched from a patient of Dr Joe Hardin of Alabama. The rash extends above the eyebrows. Although quite rare, this true butterfly rash is probably pathognomonic for SLE. **D:** Another butterfly rash from a patient with acute SLE. (Photos: David, by Michelangelo, with superimposed lesions.)

or meningitis, and their occurrence during treatment should be a warning that the advantages of the antibiotic era are being lost, partly through injudicious overprescription of antibiotics.

Percussion

Percussion of the skull is of little use except that it can diagnose a child with untreated hydrocephalus.

A Method

Tap the skull with the tip of a half-bent finger.

A hydrocephalic skull produces the "cracked pot" sound, which would more accurately be called the "ripe watermelon" sound (M. Schlitt, *personal communication*, 1998). This is known as *Macewen sign*. It is caused by separation of sutures due to chronic increase in intracranial pressure.

Axial compression by percussing the head has previously been recommended as a way of eliciting pain at a remote site of vertebral disease. Neurosurgeons discourage this because of the risk of severe spinal cord injury in a patient with a large cervical disk herniation. It is a variant of the Spurling maneuver, which is described in Chapter 25.

Auscultation

In 1928, Cushing said: "By a strange human frailty, auscultation of the skull seems to be the one thing most likely to be neglected in a routine neurologic examination. Cephalic auscultation is a forgotten practice and even when a patient calls attention to the fact that he hears noises in his head, they are so likely to be ascribed to some form of auditory hallucination or to tinnitus that the examiner rarely thinks of checking the patient's statement with a stethoscope" (Wadia and Monckton, 1957).

Valuable information may be obtained from auscultation, although interpretation of the findings is complex.

Historic Interlude

The oldest method of cranial auscultation was for the examiner to place his own ear against the ear of the patient. Still described a device by which two sets of earpieces were joined without an intervening chest piece, with one set being placed in the examiner's ears and the other in the patient's (Mackby, 1942).

A Method

In a quiet room, listen over the eyeballs by applying the bell of the stethoscope tightly so as to make an airtight seal. In alert patients, vigorous reflex blinking may cause so much adventitious noise that faint vascular sounds are obscured. To overcome this problem, ask the patient to open his eyes and look up after the stethoscope is in place. Blinking then becomes greatly reduced, while the stethoscope holds one eyelid shut, and random extraocular movements are also prevented. Also, ask the patient to hold his breath lest respiratory sounds interfere with auscultation.

Listening over the frontal regions of the skull, the temples, the mastoid processes, and the atlanto-occipital regions has also been advised (Fisher, 1957). However, an intracranial bruit that cannot be heard over the eyeballs is not very likely to be audible elsewhere. The orbits, because of their shape and orientation, act as a cranial megaphone (M. Schlitt, *personal communication*, 1998).

If you listen over the lateral occipital region, avoid inadvertent partial occlusion of the greater occipital artery because a systolic bruit may be induced in this way (Mackby, 1942).

The best place to listen to the vertebral arteries is in the supraclavicular fossae: The most common area of stenosis (which is, moreover, surgically correctable) is at the point where the vertebral branches from the subclavian. Noises originating from the carotids or the aortic valve can also be heard in the supraclavicular fossa.

Thus, a neurosurgeon's routine for auscultation is to listen over the orbits, in the supraclavicular fossae, at the carotid bifurcations, and at the second right intercostal space to determine whether sounds may be radiating from the aortic valve (M. Schlitt, *personal communication*, 1998). The latter two areas will be described in Chapters 18 and 17, respectively. (Auscultation of the skull and the neck may be carried out at the same time as cardiac auscultation.)

In some studies, auscultation was performed with the patient erect or sitting (Wadia and Monckton, 1957); others recommend having the patient supine with the neck either neutral or slightly extended (Allen, 1965).

Note the dimensions of any bruit: location, timing with the cardiac cycle, intensity, pitch, and the effect of special maneuvers.

Maneuvers that may help elucidate the source of a cranial bruit include the Valsalva maneuver, change in body position or rotation of the head, and compression of the temporal or occipital artery or jugular veins (Allen and Mustian, 1962) (see Chapter 18).

Carotid compression may provide diagnostic information (see Chapter 18) but should not be carried out as a routine maneuver; occasional serious or fatal complications have been reported, and certain precautions should be taken (Allen, 1965). These include placing the patient supine; avoiding the carotid sinus (applying compression low on the neck); using only gentle pressure; limiting the duration to less than 5 seconds; avoiding compression in patients with carotid sinus hypersensitivity, arrhythmias, or acute cardiac disease; and monitoring pulse and mental status.

Significance of Bruits

Skull bruits in apparently normal children were first described in 1834. Bruits were so frequent in children in the experience of some authors that they wondered whether absence of a bruit might be a sign of incipient or active disease. Reported prevalence varies greatly: Still found bruits in 4% of children from age 4 to 16 years; Bell, in 6% of "young children"; Osler, in 13% of children under 3 years after the fontanelles had closed; and Henoch, in 73% of rachitic children with delayed closure of the fontanelles. The authors who reviewed these studies confirmed that spontaneous bruits were frequent in children, being found in up to 60% of 4- and 5-year-old children but decreasing after age 10 (Wadia and Monckton, 1957).

In adults, evoked bruits (those occurring on contralateral carotid compression) may persist into old age, but spontaneous bruits become more and more uncommon and probably do not occur physiologically after middle life. The prevalence of spontaneous

cephalic bruits in neurologically normal adults of ages 20 to 69 was 1.3% (Wadia and Monckton, 1957).

The significance of a finding is often age dependent (Fig. 9-10). However, even in children, a bruit may sometimes be of pathologic significance (*N Engl J Med.*, 1968), as in purulent meningitis (see Chapter 26).

In adults, the most important reason for auscultation of the skull is to detect an intracranial bruit due to an arteriovenous malformation. It has been stated that careful auscultation in all patients, especially those with epilepsy, migraine, or subarachnoid hemorrhage, would disclose more such malformations (Wadia and Monckton, 1957), although these days, patients with such disorders are more likely to have had MRI than a careful physical examination. The prevalence of spontaneous bruits in patients with intracranial vascular malformations has been reported, in various series, as 5.5%, 19%, 38%, 50%, 82%, and, by Cushing, as 89% (Wadia and Monckton, 1957).

Other causes of a spontaneous bruit include high-output states (thyrotoxicosis; anemia, especially sickle cell anemia in children; anxiety states; migraine, limited to time of attack, with a normal angiogram); locally increased blood flow with arteriovenous shunting in Paget disease; occlusive cerebrovascular or carotid disease (see Chapter 18); brain tumors; increased intracranial pressure; temporal arteritis, accompanied by narrowing of the carotid siphon; and carotid-cavernous fistula and dural fistula. The last one is the only kind of pathologic bruit that the patient usually hears; the transdural sinus, which is directly adjacent to the mastoid, is most commonly involved. This condition is also the only one in which auscultation over the mastoid is likely to be helpful.

Continuous murmurs, with systolic accentuation, may be heard in carotid artery-cavernous sinus fistulas, dural fistulas, intracranial angiomatous malformations, or highly vascular tumors. They also could be a benign venous hum. Bilateral jugular venous compression generally eliminates the diastolic phase and decreases the amplitude (Allen, 1965); however, one patient with a benign venous hum stopped wearing tight collars or neckties because they accentuated the noise (M. Schlitt, *personal communication*, 1998). Any continuous murmur at the neck or orbit is likely to be significant if states of rapid circulation can be eliminated.

The mechanism for intracerebral bruits is thought to be actual or relative arterial stenosis, leading to increased velocity of blood flow and turbulence. This could be caused by a compression or distortion of blood vessels, as with a benign tumor or hydrocephalus, as well as by increased flow through an arteriovenous malformation or a highly vascular tumor.

Skull sounds can be amplified and recorded with a fine microphone placed in the external auditory meatus. This technique, called *phonocephalography*, has been used to diagnose a case of pulsatile tinnitus due to a surface cerebral angioma (Tewfik, 1983). Advances in imaging technology have probably resulted in lesser interest in techniques of this type.

Significance of Breath Sounds and Voice Sounds

Breath sounds may be louder over an area of Paget disease than over normal skull. Voice sounds auscultated over the skull are louder and of greater clarity when the stethoscope is over an osteolytic metastasis than when it is over the normal skull (Green and Joynt, 1961).

TAL ES
LA VIDA
TAL ES
LA MUERTE
LAS DIFERENTES EDADES DE LA VIDA DEL HOMBRE Y DE LA MUGUER DE DESDE SU
NACIMIENTO HASTA SU MUERTE

Figure 9-10 The Course of Life, late 18th century, shown (perhaps accidentally) on what resembles a Gaussian curve. (Reproduced from *Medicine and the Artist [Ars Medica]*, Philadelphia Museum of Art, with permission.)

Special Maneuvers: Transillumination

Transillumination requires a very bright light and a dark room. This should be obvious, but I have seen the supposed uselessness of the test demonstrated by performing it in daylight! Allow time for the examiner's eyes to become accustomed to the darkness and shield his eyes from the light source. The light from an older otoscope or the penlights supplied by drug detail men is not bright enough. Welch Allen makes a special transilluminator for this purpose. This is great if you can find one. If you screw the top off one of the current generation of halogen-lit otoscopes and use a new battery, the light may be bright enough, at least for infant skulls (M. Schlitt, *personal communication*, 1998).

The Infant Skull

A Method

Hold a very bright light to the frontal bone, the occipital bone, and both parietal bones.

A positive sign is a red-orange glow from the entire skull. This indicates either severe hydrocephalus or hydrancephaly. The test works even in black babies.

The Sinuses

A Method

To transilluminate the *frontal* sinuses, sequentially place a *very bright* penlight in the patient's supraorbital notches and compare the sides.

To transilluminate the *maxillary* sinuses, have the patient hold a very bright penlight midline in his mouth, forming a tight seal around it while you observe the relative intensity of the glows at the lower eyelids. If the light is not strong enough, the bulb may be sequentially placed at the gum line medially to the last upper molar on each side, directed toward the sinus. With this method, the light source must be sterilized between patients. Alternatively, the penlight may be placed externally at the inferior portion of each orbit, and the glow may be observed through the palate. It should be obvious that the patient's dentures must be removed.

Interpretation

The transillumination results may be reported as opaque, dull, or normal. A unilaterally opaque maxillary sinus is always abnormal (Evans et al., 1975). False positives may occur with frontal sinuses because they may develop asymmetrically; the issue must be resolved with radiographs.

Diagnostic Accuracy

While transillumination of the frontal sinuses was a better predictor of roentgenographic disease than transillumination of the maxillary sinuses, there was still considerable error (Spector et al., 1981).

Interobserver agreement has been reported as fair for maxillary sinus transillumination (simple agreement 61%; $\kappa = 0.22$). Agreement among otolaryngologists is reportedly better for frontal sinusitis (simple agreement = 95%) (Williams and Simel, 1993).

The predictive value of the test for sinusitis depends on the patient population and the training of the examiners. In a general medicine clinic, the likelihood ratio (LR) for sinusitis was 1.6 if either maxillary sinus was dull or opaque and 0.5 if both maxillary sinuses transilluminated normally. In an otolaryngology clinic, transillumination was highly useful when either maxillary sinus was completely opaque (LR = 8) or completely normal (LR = 0.04) but was less useful when the finding was dull transillumination (LR = 0.41). In these studies, the diagnosis of sinusitis was established by roentgenograms of the paranasal sinuses (Williams and Simel, 1993).

From the earlier literature, the diagnostic accuracy of transillumination of the maxillary sinuses was 68% in one large series (McNeill, 1963). In subsequent studies, false positives and false negatives have both emerged, the exact numbers varying with whether radiologic examination or puncture fluid analysis was used as the gold standard. This is an important issue because radiologic examination has a diagnostic accuracy (when compared with fluid analysis) of only 76%, 86%, and 89% in three series (Ballantyne and Rowe, 1949; Burtoff, 1947; McNeill, 1963). Furthermore, there is an interrater variability between examiners of the roentgenograms, so these figures are subject to further variability in attempted replication.

Computerized tomography has emerged as the diagnostic test of choice for sinusitis. A limited CT scan with only four slices has been shown to have a sensitivity of 81%, a specificity of 90%, a negative predictive value of 94%, and a positive predictive value of 93%—better than plain radiographs but not as good as a full CT scan (Awaida et al., 2004). For patients with complications such as an orbital infection or meningitis, MRI is more accurate (Younis et al., 2002).

In clinical practice, the limited coronal sinus CT scan, which is highly cost effective, has replaced transillumination and plain sinus films (V.L. Goltry, *personal communication*, 2004) wherever this superior technology is available.

Another Method

Transillumination is another example of the need for a special textbook on physical diagnosis for black persons. It can be very difficult to see the skin transillumination in a highly pigmented patient. If both sides fail to transilluminate well, is this due to bilateral disease or bilateral normality beneath a dark skin?

1. Have the patient close his eyes.
2. Transilluminate from the mouth (as above).
3. Ask the patient to give a hand signal if he has a perception of light and, if so, to indicate in which eye (or eyes).
4. Have the patient open his eyes and fix at a far point. If both eyes show a pupillary red reflex (with the light shining in the mouth), the sinuses transilluminate bilaterally. **Caveat:** Again, a *very strong* lamp is needed to make this test work.

The method given above for shining the light from the inferior orbital position and observing at the palate also works well for dark-skinned patients.

A Note on Head and Facial Pain

A frequent reason for clinic visits, and a common cause of disability and chronic consumption of pain-relieving drugs, head or facial pain often remains undiagnosed. Depending upon the patient's

payment arrangements, he is more or less likely to have had the "neurosurgical massage" before the pain is assigned to a category of nondiagnosis such as tension headache or possibly misdiagnosed as a migraine.

Before initiating or perpetuating a chronic process of refilling prescriptions for the analgesic *du jour*, even years into that cycle, the physician should resort to a careful history and targeted examination to seek structural causes for the pain.

Head or facial pain can originate in the cranium, neck, eyes, ears, nose, sinuses, teeth, mouth, or other cranial or facial structures. One mechanism of pain is swelling of a structure in a closed space, such as one of the paranasal sinuses. Understanding the innervation of the various structures in the head is crucial for elucidating the source of referred pain.

Pain from the frontal sinus may radiate to the vertex or retro-orbit; from the maxillary sinus, to the upper teeth or forehead; from the ethmoid sinuses, to the retro-orbit or temporal region; and from the sphenoid sinuses, to the occipital region, vertex, frontal region, or retro-orbit. Pain from the sinuses may be present only during sinus infections or episodes of nasal congestion. However, such associations may be absent. Some patients have pain with pressure changes during air travel. As the pain may be pulsating, it is frequently attributed to migraine.

Types of pain that may be surgically relieved include that from abnormal mucosal contact points in nasal and paranasal structures (Rebeiz and Rastani, 2003). The patient needs to be seen at the height of the head and/or facial pain. A limited sinus CT scan is ordered and combined with the physical endonasal examination. A septal spur impacting somewhere on the lateral wall of the nasal cavity is suspicious. The suspicion is confirmed if vigorously spraying the nasal cavity on that side, or both sides, with a solution of 4% xylocaine in oxymetazoline relieves the pain within 15 minutes. Surgical elimination of the septal to lateral wall contact can relieve the impaction syndrome headache or facial ache permanently (V.L. Goltry, *personal communication*, 2004).

Listening to the patient and reviewing potential diagnoses with an open mind, instead of repeating the impressions codified in the medical record, can allow you to succeed where many others have failed.

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CHAPTER

10

The Eye

The eye is the window on the soul.

—Talmud

Points to Remember:

- The eyes and periorbital tissues are affected by endocrinologic, immunologic, infectious, hematologic, nutritional deficiency, and other systemic diseases, as well as neurologic conditions, local neoplasms, or intrinsic ocular disease.
- Cranial nerves II, III, IV, V, VI, and VII, as well as sympathetic and parasympathetic nerves, are all involved in vision or in the motion and protection of the eye.
- When examining the fundus, you have a direct view of an extension of the brain.
- The status of the microvasculature can be examined directly in the fundus oculi, showing evidence of progression of the effects of chronic hypertension or diabetes.

Order of the Examination

Although the examination of the eyes is recorded after the examination of the head, one might want to proceed directly to an examination of the pupils, after checking the vital signs, particularly in a patient who has an altered mental status or is severely ill.

For medicolegal reasons, visual acuity should be checked before proceeding with the rest of the eye examination, especially if any instruments are to be used or any medication is to be instilled into the eye, so that impaired acuity cannot be attributed to your manipulation. In addition, medications used to dilate the pupils tend to impair accommodation of the lens, blurring the vision.

Once you have examined the pupils, measured the acuity, and ascertained that the patient does not have a contraindication to dilating the pupils, instill one drop of a mydriatic agent into each conjunctival sac, as described later in the chapter in the section on "The Anterior Chamber." Proceed with the rest of the physical examination. By the time you finish, the pupils should be dilated, ready for the funduscopic examination.

Visual Acuity

Snellen Chart

Visual acuity is generally tested by having the patient read a Snellen chart from a distance of 20 ft, alternately covering one eye and then the other. If the patient has read a line correctly with one eye, he may be asked to read it backward when testing the other eye. When there is no such wall chart, you may substitute a pocket-size card (obtainable at a medical supply store) for the Snellen chart. Such cards are designed to be held 14 in. from the patient's eyes. If the patient misses one or two letters on a line, record the results as "20/20 – 1," "20/30 – 2," and so on. A conversion for distance in meters and the percentage loss of central vision corresponding to each measure of corrected visual acuity are given in Table 10.1.

You should test the patient while he is wearing his own corrective lenses. If these are unavailable or if the vision is still poor, see whether the patient does better looking through a pinhole, which corrects refractive errors by focusing the light on the retina regardless of the focal length of the eyeball. (Just poke a hole in an index card and have the patient hold it very close to his eye. Note that the illumination has to be strong.) If the patient cannot read the largest letter on the eye chart, determine whether he can count fingers, detect hand motion, or perceive light.

For the Resident. Look through the patient's glasses at your finger, a pencil, or any object of fairly constant size that can project beyond the glasses. If the object appears smaller through the glasses, then they belong to a myope (a person whose eyeball is "too long" for its lens to focus perfectly on the retina). If it appears larger, the glasses belong to a hypermetrope (a person whose eyeball is "too short"). If the glasses are bifocals, always look through the top lenses; the bottom lenses are simply magnifying glasses, for presbyopes (persons whose lens has lost its ability to accommodate well owing to age).

Ocular Malingering and Ocular Hysteria

Is this the world's first description of blindness as a conversion symptom?

> *During the action a very strange thing happened: Epizelus, the son of Cuphagoras, an Athenian soldier, was fighting bravely when he suddenly lost the sight of both eyes, though nothing had touched him anywhere—neither sword, spear, nor missile. From that moment he continued blind as long as he lived. I am told that in speaking about what happened to him he used to say that he fancied he was opposed by a man of great stature in heavy armour, whose beard overshadowed his shield; but the phantom passed him by, and killed the man at his side.*
>
> —Herodotus, The Histories

In persons claiming to have markedly decreased vision, check several times, and look for variable results from reading the Snellen chart. If the patient claims total blindness, check for pupillary responses and optokinetic nystagmus. Some malingerers will be unwilling or apparently unable to perform the test of touching their fingertips together, although a truly blind person can perform this maneuver with ease, using proprioception.

TABLE **10.1** *Central visual acuity*

Distance in feet	Distance in meters	% loss in visual acuity
20/16	6/5	0
20/20	6/6	0
20/25	6/7.5	5
20/32	6/10	10
20/40	6/12	15
20/50	6/15	25
20/64	6/20	35
20/80	6/24	40
20/100	6/30	50
20/125	6/38	60
20/160	6/48	70
20/200	6/60	80
20/400	6/120	90
20/800	6/240	95

Many other tests have been used (Kramer et al., 1979). The first two described below can be used for patients claiming blindness in both eyes or, with the good eye patched, for patients claiming poor vision in only one eye. Neuro-ophthalmologists have many optical tricks for testing patients who claim poor vision in only one eye, as by using prisms or cylinders to "fog" the good eye. If patients simply claim reduced acuity and inability to read the lower lines of the eye chart, Dr Robert Gervais of Mesa, Arizona, starts by asking them to read the 20/10 line, which hardly anyone can read. After fiddling with a few lenses, he moves up to the 20/15 line, then the 20/20 and 20/25, telling the patient that the letters are huge and that anybody should be able to read them.

The Mirror Test

1. A mirror, of dimensions greater than 1 × 2 ft, is held close to the patient's face so that the examiner can look over the top of the mirror into the patient's eyes.
2. The mirror is rocked either from side to side or up and down.
3. If the patient has the ability to fixate (and can thus see formed objects), the eyes will move in a direction corresponding to the motion of the mirror.

The Briefcase Test

1. Walk 40 ft down the hall and tell the patient to look at your nose. (Do not ask him whether he can see it.)
2. Lift up a briefcase, a large book, a typewriter, or a large piece of colored cardboard. Ask the patient whether he can see anything. If the patient says no, his vision is so restricted that he should be unable to walk without bumping into things.

Psychological Techniques

Of course, one way to support the diagnosis of conversion reaction or malingering is to have the impairment disappear, simply with the physician's encouragement. Methods developed in a military practice could be adapted. One method is to tell the patient that he will see much better if he scans the letters on the Snellen chart from the upper left to the lower right-hand corner, instead of staring directly at them. The patient is encouraged to describe anything he can about the letter in question, even whether it is square or round. Some patients will have to be asked to guess the shape. The subject is then led to see the component parts (square or round) of each letter (even by guessing) until he is able to "see" the entire letter. He is constantly reminded to keep scanning the letter and not to stare at it.

Another such technique (Kramer et al., 1979) is "retinal rest," in which the patient is placed at bed rest in a private room and patched bilaterally. Sedatives, television, radio, company, or interaction with the ward personnel are not allowed. Daily checks of the patient's vision are said to produce dramatic results within 3 days.

Visual Fields

Checking visual fields by confrontation is a screening test primarily for neurologic defects. You may pick up serious defects of which the patient is unaware because visual acuity is preserved.

A Method

1. Instruct the patient to look at your nose.
2. Stretch your arms out, placing your hands in a plane equidistant from the patient and yourself.
3. With your fingers held in the V-for-victory sign, move your hands to the periphery of your own vision as you watch the patient's eyes.
4. Wiggle one set of fingers and ask the patient whether he sees anything move. If he says yes, ask which side.
5. Change the position of your hands, keeping them always at the periphery of your own visual fields and in the plane equidistant between yourself and the patient, checking superiorly and inferiorly. On successive trials, it is a good idea to vary the pattern, wiggling the right only, the left only, or both.

Interpretation

This crude test might detect the bitemporal defects of sellar and chiasmal disease, the homonymous hemianopia of optic tract disease, the monocular anopsia of retinal or optic nerve disease, and the field cuts of late glaucoma. (Of course, glaucoma should be diagnosed by other means before the onset of blindness.)

False negatives will occur, for example, in patients with small defects due to retinal degeneration. The method will also miss nasal scotomata, such as that caused by early glaucoma. The latter could be detected by checking each eye individually, temporally and nasally, but remember to take into account the fact that your nose does not have the same shape as the patient's. Both defects can be detected by formal visual fields testing (*vide infra*). When in doubt, always proceed to such formal testing. The time to do it is the time that you first think of it.

Wiener and Nathanson (1976–1977) noted that visual field testing was limited by failure to include tests for "impairment of color, identification of common objects and form," leading to failure to pick up significant visual field defects. Identification of common

objects is more a test of cortical function than of the visual fields. On the other hand, the failure to use colored objects may be an important criticism because changes in color field ("color desaturation") precede gross field changes. However, currently, color field testing is thought to be an issue only for the formal perimetrist. Even DeJong (1979) suggests that the field for all colors might well be the same if one could control for color intensity. In other words, a field defect can be picked up with a red marker before it is evident with a white marker, not because of the color but because the red object is less intense than the white object.

We must emphasize that the physical examination is composed of individual screening maneuvers. Formal perimetry is superior to visual fields by confrontation for the purpose of detecting all field cuts. The advantage of visual fields by confrontation, with its lesser sensitivity, is that it is quick, cheap, and convenient in the sense that it is immediately accessible to the information processor—the physician. Were the components of the physical examination to be divided among different physicians without each having immediate access to the findings of the other, there would be no point in performing physical examinations because some technologic substitute could be found for each specific maneuver. This is an important principle, a corollary of which is that in such a world certain diagnoses could never be made.

An Alternate Method

The following method was communicated to me by Dr De Juan in 1987. Rather than wiggling the fingers, hold up a different number of fingers in each hand. Ask the patient to total the number of fingers being held up. For example, if you hold up one finger on the left-eye hand (your right) in the superotemporal quadrant and two fingers in the right-eye hand in the inferotemporal quadrant, each of the possible answers ("zero," "one," "two," or "three") has immediate diagnostic significance.

Additionally, this method prevents the patient from orienting to one finger or the other, and it is a more sensitive test for retinal function. For example, a patient with a retinal detachment may be able to see hand motions but will not be able to count fingers in the quadrants corresponding to the detached retina. Finally, this is an objective measure, not relying on the patient guessing the hand motion. However, it does require a cognitively intact patient.

A Caveat. Do not use methods that fail to present peripheral targets or that present large targets in the center of the field (such as the palm of the hands) as these will consistently *fail* to pick up *large* defects that are detectable, equally consistently, by the methods above.

Central Scotomata

At the bedside, it is possible to have the patient draw out his central scotoma (blind spot) on a piece of graph paper. (The patient is instructed to delimit the area in which he can see nothing.) Dr Simon Horenstein of Missouri uses a piece of newspaper for the same purpose. The blind spot may be enlarged by drusen, tumor, peripapillary atrophy, or other conditions affecting the optic nerve.

A Case Report

I once was presented a patient who was said to have bitemporal hemianopia. Indeed, he could see no fingers wiggling in any temporal quadrant. After a negative pituitary workup, formal visual fields were reported back: the patient had nearly total blindness from long-standing glaucoma!

The house staff had omitted the Snellen card test because "he didn't wear glasses, and he didn't look like he was blind." I, in turn, had failed to proceed to monocular and nasal field testing because formal visual fields were to be done. That was a reason of sorts, but less excusable was my failure to feel the patient's eyeballs or to examine the fundus for glaucomatous cupping, discussed later in the chapter. In turn, my "excuse" was that the house staff had already "examined" the patient, and they did not look like *they* were blind....

The Lacrimal Apparatus

Inspect the lacrimal puncta (located medially) and the lacrimal sac (*inferiorly*). Infection of the lacrimal sac may cause unilateral swelling. The lacrimal glands, located superiorly and laterally, may be enlarged unilaterally from a mixed tumor or bilaterally from a sarcoidosis or Mikulicz syndrome (a variant or precursor of Sjögren syndrome).

The function of the lacrimal apparatus is checked in patients complaining of dry eyes by means of the Schirmer test. (This may also serve as a test for facial nerve function.)

The basic Schirmer test is performed in this way: Bend a strip of filter paper (41 Watman paper) so that the proximal portion can be inserted between the palpebral and scleral conjunctivae. Take care not to touch the cornea. After 5 minutes, remove the filter paper and measure the distance that the tears have migrated. For persons under age 40, the norm is 15 mm, and it is 10 mm for those over 40. Less than 10 mm is suspicious and less than 5 mm is clearly abnormal. Try to obtain a commercially available standardized kit; otherwise, you will have to standardize the filter paper because different types have different absorbencies. Even under controlled circumstances, there is a high variability in the results (Clinch et al., 1983).

Some have used topical anesthetics to reduce reflex tearing when performing the Schirmer test. This introduces numerous sources of error, including alterations in the strip wetting because of the physical properties of the instilled agent (Hodkin et al., 1994; Murphy, 1995).

Patients with Sjögren syndrome also have a decrease in the reflex tearing promoted by inserting a cotton swab (8 cm long, 3.5 mm wide at the top) into the patient's nasal cavity, slightly upward and parallel to the lateral wall. In patients with good reflex tearing, the stimulated measurement was 24.4 ± 0.9 mm, compared to a basal measurement of 3.3 ± 2.2 mm. In patients with poor reflex tearing, who were much more likely to have lymphocytic infiltration of the lacrimal glands consistent with Sjögren syndrome, the stimulated rate was 3.7 ± 2.6 mm compared with a basal rate of 1.6 ± 1.6 mm (Tsubota et al., 1996).

Persons who have nasal mucosal damage, disease, or denervation also demonstrate decreased tear production. The development of neurotrophic keratopathy in patients with trigeminal anesthesia is correlated with the loss of the nasolacrimal reflex (Gupta et al., 1997).

The Schirmer test is not necessary to confirm the diagnosis of keratitis sicca in the presence of characteristic signs, including

scanty or absent tear meniscus, debris in the precorneal tear film, superficial punctate erosions on the lower half of the cornea, and filamentary keratitis (Clinch et al., 1983).

The Eyelids and Other Periorbital Tissue

Inspection of the eyelids might reveal clues to the patient's personality (the use of dramatic eye makeup) or to the presence of various systemic diseases, as well as local diseases of interest to the ophthalmologist which is beyond the scope of this discussion. Look for xanthelasma in patients who might have hyperlipidemia (see Chapter 7). A heliotrope rash on the eyelids is seen in dermatomyositis. Can you diagnose the patient shown in Fig. 10-1?

Loss of eyelashes is typical of ocular syphilis, an increasingly common occurrence due to the acquired immunodeficiency syndrome (AIDS) epidemic.

Ectropion is an eversion of the eyelid with exposure of the conjunctival surface owing to chronic inflammation or scar formation.

Basal cell carcinoma (see Chapter 7) may involve the eyelids and other periorbital tissue, with potentially devastating results as shown in Fig. 10-2. It most commonly begins on the medial side of the lower eyelid.

In trachoma, the leading cause of infectious visual loss worldwide, conjunctival inflammation from chlamydial infection causes scarring with entropion and trichiasis so that the inturned eyelashes constantly abrade the cornea.

Abnormal Blinking and Difficulty Opening the Eyelids

The normal blink rate is up to 21 times per minute but may exceed 40 per minute in the dry eye syndrome or keratoconjunctivitis sicca. Patients with dry eye may also report difficulty opening the eyelids because of discomfort; this is to be distinguished from blepharospasm in which the patient lacks muscle control. Patients may complain of constant burning and scratchiness, as if in a smoke-filled room, but not itching. The dry eye syndrome is a feature of aging because the quality, not the quantity, of tears declines. It is also seen with thyroid disorders and is a part of Sjögren syndrome, associated with rheumatoid arthritis, and other autoimmune diseases, especially those involving the joints.

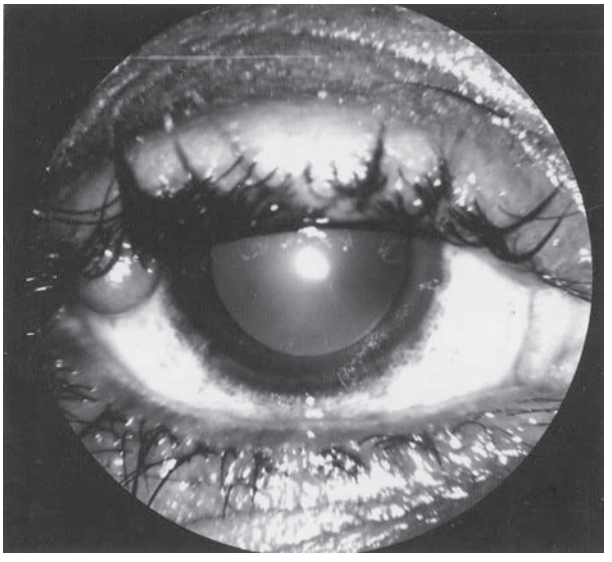

Figure 10-1 This is the external appearance of the eye of a patient whose fundi show cotton wool spots and pseudoangioid streaks (Table 10.23). Without this additional clue, it would be almost impossible to make the correct diagnosis from looking at the fundus photographs. Note the pedunculated fleshy protuberance on the upper lid. There were many of these all over the patient's body. Can you make the diagnosis? (See Chapter 7.)

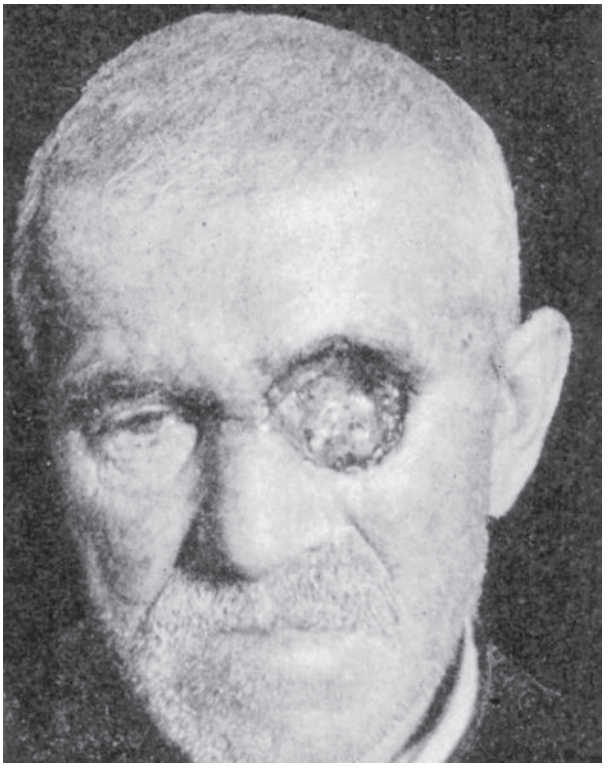

Figure 10-2 A rodent ulcer, due to locally invasive basal cell carcinoma, which has destroyed the eyeball and orbital tissues. (From De Schweinitz GE. *Disease of the Eye: A Handbook of Ophthalmic Practice for Students and Practitioners.* Philadelphia, PA: W. B. Saunders; 1915, with permission.)

Periorbital Edema

Periorbital edema is considered a useful sign for distinguishing the edema of the nephrotic syndrome from the edema of congestive heart failure, which generally spares the eyelids. The theory is that the high-protein ultrafiltrate of cardiac edema sinks, whereas the low-protein edema of the nephrotic syndrome does not. Of course, if this were the sole explanation, one would expect to see periorbital edema in severe cirrhosis, and one does not.

Unilateral edema of the palpebrae and periocular tissues with preauricular lymphadenopathy, the Romaña sign, is a classic finding in acute Chagas disease (American trypanosomiasis) when the conjunctiva is the portal of entry of the parasite. This disease afflicts some 12 million persons in Mexico and Central and South America; it is moving north with the tide of immigration to the United States, where the vector reduviid bug and infected animals are fund in many areas (Bern et al., 2007).

Other causes for periorbital edema are given in Table 10.2.

TABLE **10.2** *Differential diagnosis of periorbital edema*

Systemic edema (e.g., nephrotic syndrome)
Infectious (including sinusitis)
Bacterial: maxillary osteomyelitis, diphtheria, scarlet fever, syphilitic gumma, cavernous sinus thrombosis, mycobacterial
Viral: infectious mononucleosis
Fungal: aspergillosis sporotrichosis, mucormycosis, actinomycosis
Parasitic: trichinosis, ascariasis, onchocerciasis, malaria, syphilitic gumma, trypanosomiasis
Endocrinologic
  Graves disease (may be euthyroid at presentation)
  Hypothyroidism (no indentation with pressure)
Traumatic
  Fracture of sinuses (crepitance on palpation)
  Foreign body
Allergic (e.g., angioneurotic edema)
Neoplastic
  Acute myelocytic leukemia
  Rhabdomyosarcoma
  Retinoblastoma
  Sarcoma
  Lymphoma
  Melanoma
  Metastatic tumor (e.g., breast, lung)
  Superior vena cava syndrome

From Phillips SL, Frank E. Acute orbital pseudotumor: Ocular emergency on a general medical service. *South Med J.* 1987;80:792–793, with permission.

Palpebral Fissure

Unilateral ptosis, or drooping of the eyelid, may be a component of Horner syndrome (see later in this chapter), and unilateral or bilateral ptosis in a young person should always suggest myasthenia gravis.

Wiener and Nathanson (1976–1977) noted that many patients who were squinting were erroneously thought to have ptosis. This misadventure can be avoided by examining the patient without having him face into the light and by carefully observing the lids when performing the "up" movement of the cardinal directions of gaze. Squint is voluntary and ptosis is not. Furthermore, ptosis is unchanging, except in the Marcus Gunn jaw-winking syndrome (trigemino-oculomotor synkinesis) and its variants.

At least 256 cases of ptosis, with or without diplopia or total ophthalmoplegia, have been reported in conjunction with the use of statin drugs, with 62 positive dechallenge and 14 positive rechallenge tests. A plausible mechanism is myositis of the levator palpebrae superioris and/or extraocular muscles (Fraunfelder and Richards, 2008).

Sudden unilateral ptosis with headache may signify an aneurysm, usually of the posterior communicating artery. It is usually accompanied by a dilated pupil. Missing this diagnosis can be catastrophic.

Unilateral ptosis with pupil sparing is the hallmark of ischemic neuropathy due to diabetes (R. Gervais, *personal communication*, 2009).

For the Advanced Student. Robert Marcus Gunn was a British ophthalmologist who described a benign phenomenon probably due to a congenital aberrancy of innervation. It consists of unilateral lid ptosis in which the lid can be hyperelevated upon opening the jaw and moving the jaw to the opposite side. This is also known as the *jaw-winking reflex*. Marcus Gunn also first described the Gunn pupil.

The inverse Marcus Gunn phenomenon is the abnormal movement of facial musculature on intention to close the eyes. Alternately, the subject may find that his eye closes when he attempts to open his mouth (the Marin Amat phenomenon). This results from aberrant facial nerve regeneration or in some cases follows therapeutic transplantation of the facial nerve. Other peculiar eponymic synkinesias have been catalogued (Duke-Elder and Leigh, 1965).

A widening of the palpebral fissure may result from proptosis (*vide infra*), hypertonus of the eyelid, or a combination of the two, as in Graves disease. These factors may also cause Graefe lid lag in which the eyelids of the hyperthyroid patient seem to lag behind the globe as the patient quickly changes his direction of gaze, from the ceiling to the floor. (This sign may be easier to discern with the patient lying down, looking up toward the top of his head and then toward his toes. If he is seated, be sure that your eye level is no higher than the patient's. Try this maneuver with a control subject the first few times.)

Eyelid retraction is the most common ophthalmic feature of autoimmune thyroid disease, being present in 90% of patients at some time during their course (Brazis and Lee, 1999).

For the Advanced Student. Some authors limit the Graefe sign to a lag of the upper lid during downward gaze, calling the lag of the lower lid during upward gaze the *Griffith sign*, lagging of the globe during upward glance the *Means sign*, and any jerking of the laggard lid the *Boston sign*.

Patients with Graves disease may also have chemosis, which may be partly responsible for the infrequency of blinking in some such patients. The combination of infrequent blinking and proptosis is called the *Stellwag sign*, or *Stellwag stare*. One test for proptosis (Naffziger method) is for the physician to look down on the patient's face from a vantage point above his head to see whether the eyeballs can be observed from such a position. A hyperthyroid patient with exophthalmos is said to be able to look up at the ceiling, with the head held straight, without wrinkling the forehead (the Jeffrey sign); there may be an element of frontalis myopathy. Another sign of hyperthyroidism is Rosenbach tremor of the lightly closed eyelids.

As a general rule in medicine, a plethora of signs or tests or therapies suggest that no one of them is perfect and that possibly none of them are excellent. Usually, one should choose a few, try them on one's own patient population, and see what seems to work best.

Eye signs of Graves disease are very helpful if present, less so if absent. The positive likelihood ratio (LR) for eyelid retraction is 31.5; the negative LR, 0.7. For eyelid lag, the positive LR is 17.6; the negative LR, 0.8. For comparison, the positive and negative LRs, respectively, for a pulse of 90 or more beats per minute are 4.4 and 0.2; for warm and moist skin, 6.7 and 0.7; for enlargement of the thyroid, 2.3 and 0.1; and for fine finger tremor, 11.4 and 0.3 (McGee, 2001).

Exophthalmos (Proptosis)

The degree of exophthalmos may be measured by using the Luedde exophthalmometer (Fig. 10-3): the 99th percentiles are 19 mm for white women, 21 mm for white men, 23 mm for black women, and 24 mm for black men. An evaluation for unilateral exophthalmos is indicated if there is a measured discrepancy of at least 2 mm in white subjects or 3 mm in black subjects (De Juan et al., 1980).

The most common medical causes of unilateral exophthalmos are, in approximate order of decreasing prevalence (Grove, 1975), Graves disease; metastatic carcinoma, including paranasal sinus carcinoma in extension; hemangioma; lymphangioma; idiopathic orbital inflammation (orbital myositis); lymphoma; neural tumors (including neurofibromas); meningioma; rhabdomyosarcoma; lacrimal gland epithelial tumor; malignant melanoma; dermoids; and epidermoid tumors. Of these, rhabdomyosarcoma leads the list of children's tumors. Unilateral exophthalmos can also be a sign of basal skull fracture (see Chapter 9).

Pulsating unilateral exophthalmos is a sign of carotid-cavernous sinus fistula. Associated findings include chemosis, distention of orbital veins, impairment of vision, and a subjective awareness of a buzzing noise. This condition most commonly occurs after trauma but may result from the rupture of a saccular aneurysm (Allen, 1965).

Bilateral orbital involvement is most commonly caused by Graves disease. Other etiologies in adults include lymphoma and, less frequently, Wegener granulomatosis, vasculidites, sarcoidosis, and mycotic infections. In children, bilateral disease is most frequently the result of metastatic neuroblastoma or leukemia. Retroorbital hematoma secondary to scurvy has been reported as a cause of proptosis in a child (Suman and Dabi, 1998).

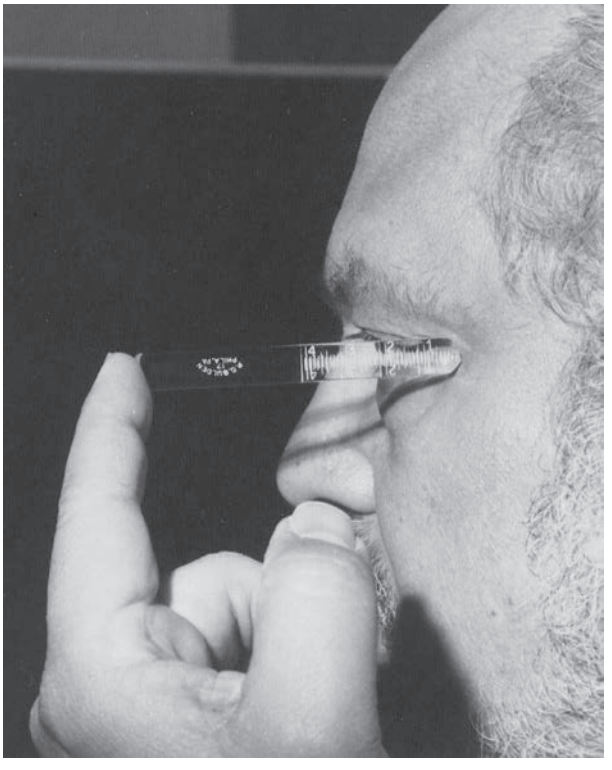

Figure 10-3 The Luedde Exophthalmometer. After the device is placed in the lateral orbital notch (the posterior-most portion of the lateral orbit), the anterior cornea is sighted through the graded plastic rod, which has markings on both sides to avoid parallax. The device need not be held with just the forefinger.

Acute orbital swelling (acute orbital pseudotumor), with ocular pain, proptosis, chemosis, impaired ocular mobility, and optic neuropathy, usually unilateral, is a medical emergency (Phillips and Frank, 1987). Emergent referral to an otolaryngologist or neurosurgeon may be required. It is most commonly caused by orbital cellulitis due to sinusitis, which should be accompanied by tenderness over the frontal sinus, fever, and leukocytosis. In diabetics, think of mucormycosis. Acute proptosis can also signal bleeding into an orbital tumor or from a carotid-cavernous sinus fistula.

An ophthalmic condition producing this picture is posterior scleritis, which can extend to damage the retina. If a computed tomography (CT) scan or magnetic resonance imaging (MRI) has ruled out emergent conditions, treatment of scleritis with massive doses of steroids should bring dramatic relief in about 12 hours.

Extraocular Movements

Cardinal Directions of Gaze

By testing only six directions of gaze, one can test six different ocular muscles, as well as the three cranial nerves that control them. These directions are northeast, east, southeast, southwest, west, and northwest, but *not* directly north or south (up and down). These directions are shown on the right eye in Fig. 10-4, at which you may now glance *briefly*, only for the purpose of seeing the six directions. There are times when we test the subject's ability to look directly up or down, but these are not cardinal directions of gaze. For additional information, see the neurologic examination. The six muscles are arranged to move around three axes, so oriented as to allow medical students to read large volumes of print without having to move their heads continuously in the fashion of a cobra following a mongoose.

In assessing horizontal excursions of the globe, abduction is normal if the corneal limbus touches the outer canthus. If some of the cornea is hidden, abduction is excessive; if some of the sclera is visible, abduction is limited. In adduction, an imaginary line between the inner third and outer two thirds of the cornea should coincide with a vertical line through the lower lacrimal punctum (Brazis and Lee, 1999).

The lateral rectus moves the globe laterally, and the medial rectus moves it medially, corresponding to the east and west directions. This much is not in dispute. The superior oblique (SO), despite its name and its reputation among morbid anatomists, actually moves the eyeball down and in. This has been a mystery to some (mysteries often have a spiral staircase, which goes *down and in*), but nonetheless is clearly true (Sapira, 1979; Younge and Sutula, 1977). The inferior oblique moves the globe up and in (superiorly and medially). The superior rectus moves the globe up and out (superiorly and temporally). The inferior rectus moves the globe down and out (inferiorly and temporally). This much is true. The following statements are generally true

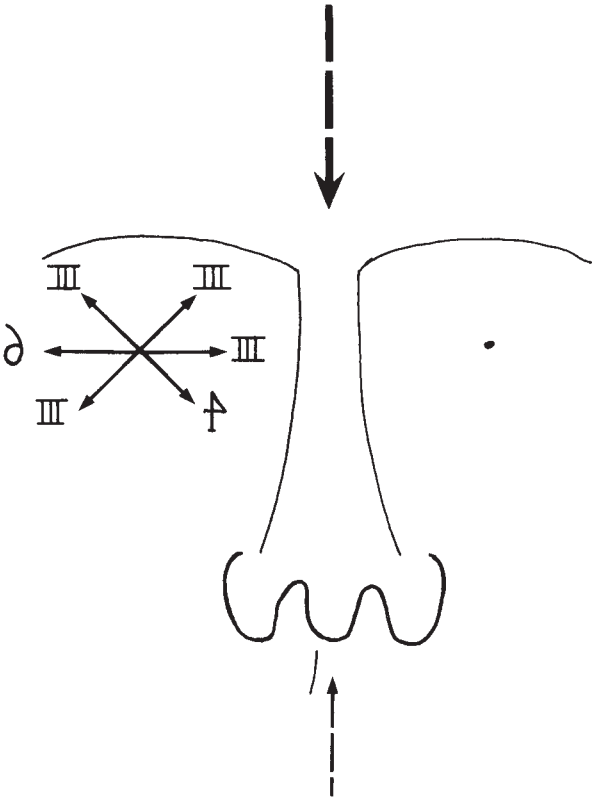

Figure 10-4 The cardinal directions of gaze. Instructions:
1. Place a hand mirror on the arrows down the middle of the nose, the reflecting surface to your left (the face's right eye). Keep that side hidden while you work on the face's left eye.
2. Draw in the cardinal directions of gaze on the face's left eye.
3. For those directions that are unique to a cranial nerve, write the number of vthe cranial nerve in Arabic numerals.
4. Designate the remainder of the cranial nerves in Roman numerals.
5. Now, you may look at the right eye. The correct answers for the left eye will be given in the mirror.

but incomplete. They will generally lead to the correct answer or one that is not entirely wrong: the "upward" movement of the globe is by the superior rectus and the "downward" movement by the inferior rectus. (To understand why these statements are not false, but not exactly true, you need to review the anatomy and physiology of the eye.) The testing of the cranial nerves is done by inference from knowledge of the anatomy of the muscles. All are supplied by cranial nerve III, except for the SO, which is supplied by cranial nerve IV, and the lateral rectus (LR), which is supplied by cranial nerve VI. The mnemonic is "LR sulfate," spelled LR_6SO_4.

Superior Oblique Palsy

A patient with a right SO palsy, due to an isolated lesion of the trochlear nerve, is shown in Fig. 26-3A, which illustrates the spontaneous Bielschowsky head tilt sign (Younge and Sutula, 1977). The head is tilted down toward the side away from the lesion. This spontaneous sign has a 50% sensitivity. However, if you remember to tilt the head back the other way (down toward the side of the lesion) and look for the iris on the bad side to move superiorly, the test is positive in 94% of the cases (Fig. 26-3B).

Figure 10-5 Right pseudoinferior oblique palsy due to Brown syndrome, in a patient of Dr Bruce McClain of Washington, DC.

False Positives

A *spontaneous* head tilt could also be idiopathic or due to torticollis (see Chapter 25), but keep in mind that ocular problems also cause torticollis, eventually leading to changes in the neck muscles.

All cases of torticollis of unclear etiology should have an ophthalmic evaluation. Underaction of the SO muscle was the most common ocular cause of torticollis in a series of 188 patients. Patients with nystagmus may also have torticollis to maintain a position of gaze in which the amplitude of the nystagmus is minimized (Williams et al., 1996).

Apparent Inferior Oblique Palsy

Brown syndrome (Figs. 10-5 and 10-6) is an unusual manifestation of rheumatoid arthritis, which is probably due to a stenosing tenosynovitis[1] of the SO tendon and sheath. The patient intermittently has vertical diplopia, a clicking sensation, and an apparent inferior oblique palsy. The eye is able to look down and medially but sometimes becomes trapped in that position. When the patient then attempts to look up and medially, the trapped eye acts as if it has an inferior oblique palsy. With continued effort, the eye sometimes is able to pop loose, snapping all or part of the way up. The patient feels a click, and the physician might be able to palpate it at the orbit's upper medial corner (Killian et al., 1977). Because there is no true inferior oblique palsy and because both the intermittency and the clicking sensation sound unusual, the unaware skeptic might be tempted to dismiss the patient or administer an unneeded psychotropic medication.

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[1]The word "synovium" comes from the Greek *syn* (with) and the Latin *ova* (egg). The synovial fluid, originally called the *synovium*, looked like the white of an egg, that is, the stuff that came *with the egg*. Later, the word was transferred to the lining of the joint, which was thought to make the synovium, and the lining came to be called the *synovium* (instead of synovial lining, i.e., the lining that makes the synovium), and that which was previously called the synovium became the *synovial fluid*. (This is very similar to what happened to "ventricle," which means sack and is used by cardiologists alternately to mean the sack itself or the space [cavity] contained by the sack.)

Brown syndrome could also be called a *tenovaginitis*. The word "vagina" underwent a similar evolution. The vagina was the sheath or scabbard that the Roman carried around his waist to hold his sword. As defined in the older anatomy books, there were many vaginas, only one of which is now called by that word. To have said "gonorrhea is a common disease of *the* vagina" would have been incorrect because there was in those past days no single vagina to justify use of the singular definite article.

FIGURE 10-6 Same patient as in Fig. 10-5. The left eye is normal.

Weakness of Convergence

The Möbius sign of hyperthyroidism is a weakness of ocular convergence during near accommodation (about 5 in. away). This occurs because of a myopathy involving the medial recti.

Strabismus

Strabismus is a disorder of gaze in which one eye deviates from parallelism with the other. It may be paralytic or nonparalytic, the former being caused by specific oculomotor palsies. In nonparalytic strabismus, the relative abnormality of the two globes appears to remain constant over a fairly wide angle of vision, and each eye can move in all four quadrants.

A Method

An easy way to check for strabismus is to have the subject look at a penlight about 3 ft away. The reflection of the light should come from approximately the same part of each pupil. This is called the *corneal light reflex test* or the *Hirschberg test*. A more sensitive test is the "cover test" (*vide infra*).

An asymmetry in the corneal light reflection may also be a sign of a subtle displacement of the globe, because of an orbital tumor (Gariano et al., 1993). Nonparalytic convergent strabismus ("cross eyes") is called *esotropia*. Divergent strabismus ("wall eyes") is *exotropia*. In the vertical dimension, the aberrant eye may point up to the ceiling (hypertropia, not to be confused with hypermetropia [hyperopia] discussed previously) or down at the floor (hypotropia).

The various tropias may result in amblyopia, which is reduced vision due to suppression of the image from the deviating eye so as to avoid the discomfort attendant upon diplopia (double vision). It is extremely important to discover tropias very early in childhood in order to prevent permanent loss of vision. Specific testing is needed, as only half the children with strabismus have a noticeable abnormality in the appearance of the eyes (Essman and Essman, 1992).

Strabismus is a presenting sign in 20% of cases of retinoblastoma (Essman and Essman, 1992).

Latent Strabismus

Latent strabismus is given the suffix "phoria" instead of "tropia." It is usually not detected by routine physical examination and is often of no clinical significance. However, in some cases (e.g., SO palsy, Brown syndrome, etc.), there are some fields of gaze in which there is single vision. In other fields of gaze, however, the phoria becomes manifest or tropic. Therefore, in any patient who complains of double vision, a cover test may give the first clue to an underlying cranial nerve lesion or other etiology of the diplopia.

The Cover Test: A Method

1. Sit directly in front of the subject and ask him to look at a light or a brightly colored object 2 to 3 ft away.
2. Cover one of the subject's eyes while observing the uncovered eye for any movement. If it moves quickly to assume fixation, a manifest strabismus is present. An outward movement demonstrates an esotropia and an inward movement demonstrates an exotropia.
3. Now, move the cover across to the other eye and watch for the motion of the eye that is now uncovered. (Actually, this test might better be called the "uncover test.") Any movement suggests that the eye deviated when binocular vision was blocked, indicating a latent strabismus. (A small degree of exophoria—the eye moves in when the occluder is removed, when looking at objects close by—is not necessarily abnormal. Esophoria or a large exophoria is a cause for concern and prompt referral.)
4. Repeat, starting with the opposite eye.

Compare the red reflex images in a color photograph for symmetry and color. Asymmetric red reflexes may indicate strabismus (Essman and Essman, 1992).

Types of Eye Movements

There are two basic types of eye movements: rapid movements and slow or pursuit movements. The former involve corticobulbar pathways and are used to bring new images onto the fovea. These are called *saccadic movements* or *saccades*; the word "saccadic" comes from a French term meaning to stop a horse by giving its reins a quick jerk. Slow movements are cerebellar/vestibular in origin and are used to hold an image stationary on a moving retina.

Nystagmus

Nystagmus refers to slight, rapid, rhythmic, and "spontaneous" (involuntary) movements of the eyes. The movements often have a slow (vestibular) deviation component and a quick (cerebral or saccadic) return component. Some authors name nystagmus for the direction of gaze in which the nystagmus appears; others name it for the quick return component (see Chapter 4). For this reason, it is probably best simply to describe the nystagmus.

Nystagmus of acute onset is basically a neurologic sign but is included here because it is discovered in the routine examination of the extraocular movements. It indicates disease somewhere in the vestibular–cerebellar–oculomotor system, either structural or toxic; the differential diagnosis is given in Chapter 26.

In patients who are otherwise normal, nystagmus, either horizontal or rotatory, may be congenital. It is more noticeable on slit-lamp examination. The patient may report only some slight blurring of vision, but if one eye is occluded, the nystagmus becomes very prominent and measured visual acuity may drop to 20/200.

Other brainstem signs involving the central control of ocular position, such as doll's eyes and caloric stimulation, are discussed in Chapter 26.

A Method

Nystagmus may occur (ominously) in the primary position (at rest), but it is usually evoked by holding the patient's head and having him visually follow a *rapid* finger movement, first horizontally and then vertically. When testing for nystagmus on lateral gaze, you do not have to go very far laterally. Significant nystagmus will occur within 30 degrees of the primary position.

Some Definitions

In *horizontal nystagmus*, the oscillation is from side to side (as in patients given hypnotic sedatives). In *vertical nystagmus*, the oscillation is up and down, and in *rotatory nystagmus*, the motion is circular.

Vertical nystagmus may signify a medical emergency, Wernicke encephalopathy (see Chapter 26).

Fixation nystagmus is present only when looking at an object.

Pendular nystagmus lacks a quick or slow component (i.e., both movements are equal in rate and speed). It is found in a variety of conditions in which central vision is lost early in life, such as albinism.

Downbeat nystagmus is a vertical jerk occurring in the primary position and is usually exacerbated by lateral or downward gaze (see Chapter 26).

Nystagmoid movement is a false nystagmus of up to three beats, never more, which can occur in normal individuals on initially looking to an extreme position. *Blind-eye nystagmus* refers to the irregular oscillations sometimes seen in a blind eye. These go away if the blind eye is asked to "look" at a fixed point and is thus a false nystagmus.

Gaze-paretic nystagmus is also a false nystagmus, due to weakness of the oculomotor muscles. It resembles the postdisuse weakness of larger striated muscles. It is best elicited by having the patient look in a direction that requires the use of the paralyzed muscle. In *gaze-paretic nystagmus*, both eyes show more nystagmus to one end position than to the other. This accompanies lesions that produce paralysis of conjugate gaze and has no significance beyond that of the paralysis. *Physiologic nystagmus* occurs when persons in a moving vehicle stare past a fixed portion, such as the edge of the windshield, at a repetitive, quickly moving background, such as poles, tunnel arches, trees, and so forth.

Optokinetic nystagmus is a physiologic response elicited by having the patient gaze at a rotating vertically striped drum. The unilateral absence of this nystagmus is a clue to the abnormality of the ipsilateral oculomotor nucleus and nerve. Cerebral lesions involve loss of this nystagmus only when the drum is moving toward the affected side. It is also useful in cases in which a patient claims total loss of vision and who therefore should not have any optokinetic nystagmus but in fact does.

An optokinetic drum can be constructed out of a roll of chart labeling tape if the labels have a colored stripe (a method shown to me by Dr Cheolsu Shin of North Carolina). The tape is placed around a pencil and held erect on its axis; the tape is then unwound at a constant rate.

Abnormal Saccadic Eye Movements

Involuntary saccades may be confused with nystagmus. Special forms include ocular flutter, opsoclonus, and saccadomania (Leigh and Zee, 1983). In opsoclonus, the saccades are arrhythmic, multidirectional, and of high amplitude. Opsoclonus may occur with encephalitis, trauma, intracranial tumors, thalamic hemorrhage, hydrocephalus, or toxic and metabolic encephalopathy. It may be a paraneoplastic or remote effect of neuroblastoma in children or of ovarian, lung, or breast cancer in adults.

Saccadic movements may be slowed in AIDS patients (Nguyen et al., 1989).

The Sclera

Scleral Icterus

Scleral icterus is a misnomer because one actually is observing icterus of the bulbar conjunctiva against the white background provided by the sclera. A whole school of one-upmanship has evolved around the question, "Where is the best place to look for jaundice?" Some say the palms, others say the roof of the palate, and still others champion the tympanic membranes. I usually answer "in the parking lot." By this I mean that the most important issue is not which portion of the body is being examined (although I still favor the scleral conjunctiva) but the quality of the light that is used. As a student, I missed icterus in patients with a measured serum bilirubin as high as 8 mg per dL (137 mmol per L) if I examined them at night in a room dimly lit by incandescent bulbs in the ceiling. Fluorescent light bulbs at night are not much better. In natural daylight, one can perceive levels of 4 mg per dL (on a cloudy day or in a poorly lit room). In the Midwest, in direct sunshine filtered through haze, one can get into the range of 2.3 to 2.1 mg per dL of bilirubin. In sunny Southern climes on the side of the building struck by the sun, one can detect as little as 1.5 to 1.7 mg per dL. Using a standardized penlight in rooms lit by incandescent bulbs, only two thirds of examiners were able to detect scleral icterus at a bilirubin level of 2.5 mg per dL (42.89 mmol per L) (Ruiz et al., 1997).

Self-teaching Exercise

On a sunny day, find a patient with a total serum bilirubin of around 2 to 3 mg per dL. First, examine the scleral conjunctivae in artificial light in a poorly lit room. Then walk the patient to a window on the sunny side of the building and reexamine his eyes in *direct* sunlight.

Black patients may normally have a brown or muddy pigmentation, which appears to be scleral but is actually conjunctiva. Ignore this. Instead, have the patient gaze superiorly or interiorly and examine the portion of the bulbar conjunctiva that is not usually exposed to sunlight. Those portions will not have the brown muddy pigmentation but will clearly show the yellow pigment of icterus, if present.

For the Attending. The pigment that is observed is not the serum bilirubin but the bilirubin deposited in tissues. When the serum bilirubin is rapidly changing, the scleral icterus will tend to lag behind. This will improve your roundsmanship when the patient's bilirubin is dropping because you may be able to see scleral icterus at a time when the serum bilirubin has dropped almost to the upper limit of normal. On the other hand, you will be less impressive when the serum bilirubin is rising.

Spots on the Sclerae

Pingueculae and pterygia (*vide infra*) actually arise from the conjunctiva; they are frequently misperceived to be scleral in origin.

Pigmented spots medial and lateral to the limbus may be seen in ochronosis or in Gaucher disease. Senile hyaline plaques, a simple degenerative phenomenon occurring after the age of 50, have no systemic or ocular significance. They are characteristically found at the insertions of the medial and lateral rectus muscles and so are more discrete and rectangular than the pigmented spots of ochronosis or Gaucher disease.

White spots like Brie cheese, usually located only on the temporal side, are called *Bitot spots*. They are seen in vitamin A deficiency and are thus exceedingly rare in developed countries. If the deficiency is not corrected, irreversible melting of the cornea can occur. Worldwide, vitamin A deficiency is a major problem, with attributable mortality of 1 to 2.5 million children annually. Night blindness is the earliest sign, followed by conjunctival xerosis (Congdon et al., 2003).

Blue Sclerae

Blue sclerae have been called pathognomonic for osteogenesis imperfecta, but this is not true. Moreover, patients with type 4 osteogenesis imperfecta do not have blue sclerae; it is important to recognize this lest fractures be misdiagnosed as nonaccidental injury (Paterson et al., 1983).

In 1908, Osler described the association between blue sclerae and iron-deficiency anemia. A study of 169 hospitalized patients showed blue sclerae in 87% of patients with iron-deficiency anemia, in 7% of patients with other anemias, and in 5.3% of patients without anemia (Kalra et al., 1986).

Blue sclerae are also seen in 3% of patients with Marfan syndrome (Cross and Jensen, 1973; Hanno and Weiss, 1961), in 15% of cases of pseudohypoparathyroidism (Scheie and Albert, 1977), in 5% of cases of homocystinuria (Cross and Jensen, 1973), occasionally in Ehlers–Danlos syndrome (Paton, 1972; Thomas et al., 1954), and very rarely in pseudoxanthoma elasticum (Paton, 1972; Roy, 1972; Scheie and Albert, 1977). They may be seen with mitoxantrone therapy (*Med Lett Drugs Ther*, 1988), corticosteroid therapy, myasthenia gravis, and various collagen vascular disorders (Kalra et al., 1986). Other very rare causes of blue sclerae that are of potential interest to the nonophthalmologist include oxycephaly (Walsh and Hoyt, 1969), incontinentia pigmenti, Turner syndrome, hypophosphatasia, Crouzon disease, Hallermann–Streiff syndrome, pycnodysostosis, and the ocular staphylomas (Roy, 1972).

Possibly, blue sclerae are also seen in pseudohypoparathyroidism, but ophthalmologists have unsuccessfully sought such an association (Hanno and Weiss, 1961). It may have gained entry to the differential diagnosis when a well-meaning medical secretary decided that the proper diagnosis, pseudo-pseudohypoparathyroidism, was a *lapsus linguae* of the dictator and so amputated one of the "pseudos."

Finally, this discussion is concerned with truly, abnormally blue sclerae. Many persons have a light-blue tinge to their sclerae, and with a good light, an attending physician can probably find a bluish scleromalacia in patients with rheumatoid arthritis or (with a little imagination) even in red-haired persons with hypertension. (By the 16th century, portrait painters knew to add blue to the white of the eyes of normal subjects [Burckhardt, 1929].) Do not push the physical examination beyond its capacity.

Scleritis

Anterior scleritis is much easier to diagnose than posterior scleritis (*vide supra*) because a red patch on the sclera, without evidence of iritis, can be seen. Treatment with steroids is indicated to prevent retinal damage.

The Conjunctiva

Examination

The conjunctiva covers the entire anterior eyeball, with the exception of the cornea. For convenience, one may speak of the bulbar conjunctiva, which covers the sclera and the palpebral conjunctiva.

Methods

Inspect the fornices and the lower palpebral conjunctiva by simply pulling down the lower eyelid. This is done, *not* by touching the lower eyelid, but by pressing the skin overlying the inferior orbital maxilla against its underlying bone and then tugging this skin inferiorly. The eyelid will evert.

If there is inflammation of the eye, or any other reason to suspect a foreign body, the conjunctiva of the upper lid must also be inspected, by everting the eyelid. Ask the patient to look down and grasp the upper eyelashes gently with the thumb and forefinger of one hand. Using a cotton swab placed at the upper border of the tarsal plate as a fulcrum, pull up on the lashes and push down on the tarsal plate. Later, when the patient looks up, the eyelid will flip back to its normal position.

If the patient has difficulty opening the eye, say after trauma, obtain two wooden-handled Q tips, and lay them on the upper and lower eyelid, well away from the palpebral fissure. Roll them toward the fissure, and the eyelids will open. Do not put pressure on the globe.

Findings

Examining the palpebral conjunctiva in bright direct sunlight will enable you to estimate the hematocrit; this is especially helpful in patients in whom fingernail abnormalities complicate the examination of the nail bed.

A pterygium (from the Greek word for "wing") is a fan-shaped or wing-shaped proliferation of opaque fibrovascular conjunctival tissue almost always medial to the iris and in some cases growing over the cornea, where it may interfere with vision. A pinguecula (from one of the Latin words for "fat") is a collection of fat, medial or lateral to the iris, which does not extend onto the cornea. It is not ophthalmologically ominous or systemically significant.

The ophthalmoscope may be used to inspect that bulbar conjunctiva usually covered by the lower lid for the corkscrew vessels of the sickle hemoglobinopathies. The test is 91% sensitive for hemoglobin S disease, is less sensitive for heterozygotes, and has no false positives (Comer and Fred, 1964).

Hemorrhages on the palpebral conjunctiva may be a sign of systemic infection, such as bacterial endocarditis.

Nothing is so dramatic as a large bright red bulbar conjunctival hemorrhage that suddenly blossoms where none was seen before but where it cannot be ignored. It is not vision threatening, although it may be associated with a number of systemic diseases.

The most common cause is local trauma, although it may be a sign of remote trauma, as in subarachnoid hemorrhage.

If it appears more than 1 day after the trauma, it is pathognomonic for basal skull fracture. (The sensitivity for basal skull fracture is 10% [Duke-Elder and Leigh, 1965].) It may also appear after acute venous hypertension (severe coughing) or sustained venous hypertension (e.g., superior vena cava syndrome) or as a local manifestation of a systemic vasculitis, thrombocytopenia, or clotting disorder. In the latter conditions, conjunctival hemorrhage never occurs in isolation but always in the presence of other signs. Kaposi sarcoma may present as a nonclearing subconjunctival hemorrhage; about 20% of patients with this tumor have involvement of the eyelids or palpebral conjunctiva, where a fleshy red mass may be seen (Gariano et al., 1993).

There is evidence (Duke-Elder and Leigh, 1965) that the vessels of the conjunctiva become more fragile with diabetes mellitus, hypertension, or simply aging. Thus, it is not surprising that one of the most common conclusions in investigating isolated conjunctival hemorrhage is "no known explanation and no known pathology."

Chemosis

Chemosis is a Greek word meaning conjunctival edema, derived from the classic Greek word meaning to yawn, gape, or stare, which became a slang word meaning mollusc or bivalve (whose shell might gape apart). This was considered a fine analogy to conjunctival edema, with the two shells corresponding to the eyelids. Sometimes the chemosis is unaccompanied by lacrimation, so that the conjunctiva looks wet, but no tearing can be seen. Hence, the wetness is within the conjunctival tissue per se.

A Method

To demonstrate chemosis, rub the palpebral conjunctiva of the lower lid upward against the bulbar conjunctiva, keeping your finger on the skin of the lower lid. This will cause the boggy, waterlogged bulbar conjunctiva to heap up on itself. The corrugated appearance may be easily seen when obliquely illuminated with a good light.

Etiologies of chemosis include increased vascular permeability, increased venous pressure, decreased plasma albumin, and metabolic afflictions of the periorbital tissue. Increased vascular permeability may either be systemic or local (from inflammation of the eye or neighboring tissues, possibly including the meninges). The systemic causes include infections, hypersensitivity reactions, and Quincke angioneurotic edema. It is said that chemosis may be a valuable early sign of meningitis (Duke-Elder and Leigh, 1965).

Venous congestion may result from a cause within the orbit, or it may be a very valuable sign of the superior vena cava syndrome. In pure right-sided heart failure (due to tricuspid stenosis, constrictive pericarditis, cardiac tamponade, etc.), rarely, very mild chemosis may be seen. It may occur in nephrotic syndrome but is not seen in pure left-sided ("backward") congestive heart failure, which produces edema of a high protein concentration. In chronic cases, the conjunctiva takes on a yellow hue.

The two metabolic afflictions of the orbit that cause chemosis are Graves ophthalmopathy and myxedema. Unilateral chemosis can be a sign of anterior basal skull fracture (see Chapter 9).

The Cornea

The cornea should be clear and smooth. In patients complaining of a painful, red eye (*vide infra*), the physician must inspect the cornea carefully for foreign bodies, abrasions, ulcers, or signs of herpetic infection. Be aware that atopic patients have unusual susceptibility to both ocular and nonocular herpes simplex and that ocular herpes simplex in atopic patients is often bilateral (Garrity and Liesegang, 1984).

Special Maneuvers

The dendritic-appearing corneal lesion of herpes simplex is best discerned by touching the palpebral conjunctiva with a moistened fluorescein strip and looking for staining. (Fluorescein staining is also helpful for seeing corneal abrasions due to trauma.)

The corneal reflex is discussed in Chapter 26. Ophthalmoscopic examination of the cornea, including the findings of interstitial keratitis, is discussed later in this chapter.

Interstitial Keratitis

Interstitial keratitis due to congenital syphilis has an acute onset, usually between the ages of 5 and 25 years and most often near puberty, with pain, photophobia, and circumcorneal injection followed by vascularization of the cornea with the result shown in Fig. 10-7. This accompanies two other signs—labyrinthine deafness and Hutchinson notched incisors (Hutchinson, 1859). However, keratitis and vestibuloauditory symptoms, in the absence of the characteristic teeth, may occur in the adult as part of Cogan syndrome (Vollerstein et al., 1986). The above instances of keratitis are bilateral. However, unilateral, isolated keratitis may rarely occur due to either acquired (not congenital) syphilis or tuberculosis.

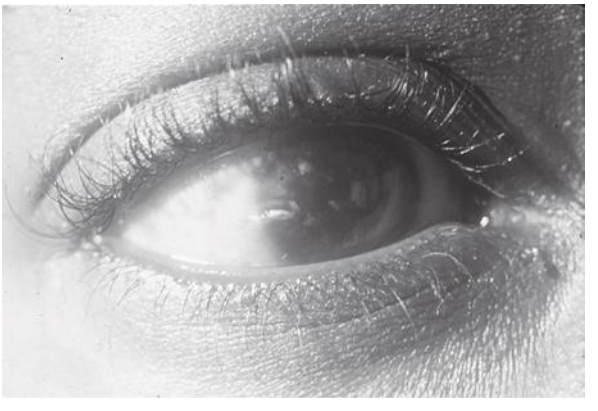


Figure 10-7 Interstitial keratitis due to congenital syphilis, with resulting blindness. The cornea develops a ground-glass appearance with vascularization of the adjacent sclera. (From Public Health Service, US Department of Health. Education, and Welfare. *Syphilis: A Synopsis.* Public Health Service Publication No. 1660, Washington, DC, 1968, with permission.)

Band Keratopathy

Band keratopathy is a white cloudiness of the afflicted area of the cornea, resembling the fine precipitate of calcium phosphate (in a test tube) or the haze of a London sunrise. It can be seen with the naked eye if one examines the cornea in a good light. The horizontal band of the cornea that is exposed to sunlight is afflicted, while the protected portion usually remains as sparkling clear as aspic. Sometimes the keratopathy extends to the conjunctiva but only in severe cases.

Band keratopathy is seen in many hypercalcemic states, including primary hyperparathyroidism, sarcoidosis, vitamin D intoxication, and milk-alkali syndrome (Cogan et al., 1948); in berylliosis, multiple myeloma, Hodgkin disease (Walsh and Hoyt, 1969); and most quickly (within 4 months) in infantile hypercalcemia (Duke-Elder and Leigh, 1965). Band keratopathy remains even after the serum calcium has returned to normal.

Other causes of the dystrophic calcification type of band keratopathy include secondary hyperparathyroidism (Cogan et al., 1948); Paget disease; hypophosphatasia (Duke-Elder and Leigh, 1965); "acute osteoporosis" (Roy, 1972); and renal failure with nephrocalcinosis or nephrolithiasis due to the milk-alkali syndrome, secondary hyperparathyroidism, or perhaps cystinosis (Roy, 1972).

Band keratopathy has also been seen in juvenile rheumatoid arthritis (Scheie and Albert, 1977; Walsh and Hoyt, 1969) but in fewer than 1% of cases of adult rheumatoid arthritis (Roy, 1972; Smith, 1957). It has occurred in discoid lupus erythematosus (Roy, 1972) and, on one occasion, in gout (Fishman and Sunderman, 1966). Very rarely, it has been reported in tuberous sclerosis (Duke-Elder and Leigh, 1965), ichthyosis (Roy, 1972), Rothmund syndrome, Parry–Romberg syndrome (Roy, 1972), and pulmonary tuberculosis (Duke-Elder and Leigh, 1965), although the last is now known to produce hypercalcemia on occasion (Shai et al., 1972).

Ocular disorders that can cause band keratopathy include 3% to 5% of cases of peripheral uveitis (pars planitis) (Brockhurst et al., 1960; Schlaegel, 1978), interstitial keratitis, phthisis bulbi, chronic iridocyclitis (Roy, 1972), sympathetic ophthalmia (Pau, 1978), absolute glaucoma[2] (Pau, 1978), and toxoplasmosis (Schlaegel, 1977). Band keratopathy can be associated with any type of corneal injury, whether toxic, thermal, traumatic, or so on (E. De Juan, *personal communication*, 1987). Among the posttraumatic ocular causes of band keratopathy are postburn and postperforation (Pau, 1978), toxic fumes (mercury, calomel, calcium bichromate), and particle irritation, for example, in hatters who cut rabbit fur with scissors (Duke-Elder and Leigh, 1965). Finally, there are recognized families with band keratopathy (Duke-Elder and Leigh, 1965), as well as instances of "idiopathic" band keratopathy (Roy, 1972).

The Limbus Sign

Although band keratopathy is the best known sign of hypercalcemia, I am personally more impressed with the utility of the limbus sign (Fig. 10-8), a ring of dystrophic calcification best seen as a milky precipitate at the limbus (Pau, 1978; Roberts, 1958; Schumacher and Scheler, 1969). The limbus sign has almost been forgotten by modern professors of medicine and even when stumbled upon by a thorough examiner is usually misinterpreted as arcus senilis, which it closely resembles. This sign may be present in situations like chronic renal insufficiency wherein the absolute value of the serum calcium is within the normal range, yet still inappropriately high for the clinical situation, as demonstrated by the elevated calcium–phosphate product (Schumacher and Scheler, 1969). The limbus sign is permanent and persists even after the calcium–phosphate product has returned to normal.

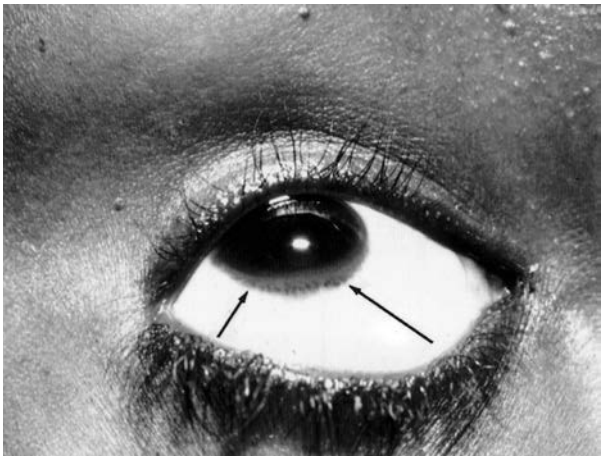


FIGURE 10-8 This 24-year-old woman had an elevated calcium–phosphate product because of renal disease but no lipid abnormalities. A milky arc (the limbus sign) can be seen obscuring the underlying dark iris, sweeping interiorly between the two arrows. (Courtesy of Dr David Johnson of Tennessee, with permission.)

Arcus Senilis

Arcus senilis is a white ring at the limbus, which begins as an arc, hence its name. The modifier indicates the belief that the finding is a degenerative sign, although, more accurately, it correlates with aging. It was found to be absent in hospitalized black men under age 15, in white men under 50, in black women under 30, and in white women under 40. In a steel mill, arcus senilis was absent in black men under 20 and white men under 30 (Macaraeg et al., 1968). Thus, the term is inaccurate for blacks, who develop the sign earlier than whites, and also for women, for whom the Latin term for aging is *anilis*.

It was thought that arcus senilis signified vascular disease, which also varies with age, through what I refer to as the Bayesian fallacy, a belief that all findings are independent of each other. Thus, young people rarely have vascular disease or arcus senilis, while older people frequently have both; hence, the arcus is taken to be a sign of disease. However, if this were true often enough to be clinically useful, it would be easy to show the claimed correlation, but it is not, although there is some evidence for it. Currently, the best correlation seems to be with electrocardiogram abnormalities (Macaraeg et al., 1968; Rodstein and Zelman, 1963), which are still one step removed from specific diseases with specific names.

Kayser–Fleischer Ring

The occurrence of a brownish-green ring, at or near the limbus, represents copper deposition in Descemet membrane. This ring, described by Kayser and Fleischer, has high positive and negative predictive values for the diagnosis of untreated Wilson disease. It is visible to the naked eye without special arrangements, time,

[2] Absolute glaucoma means a totally blind eye, often painful.

equipment (i.e., a slitlamp), or cost, although slitlamp examination is more sensitive.

False Positives

The emphasis here is first on the color green. Bilirubin and carotene have produced false-positive Kayser–Fleischer rings by "staining" a white arcus senilis background (Weinberg et al., 1981). We can thus predict the subsequent report of a similar false positive due to lycopenemia in a tomato juice addict with arcus senilis. Yet none of these pigments is truly green. Bilirubin is yellow orangish, carotenes are orange, and lycopenes are reddish. Finally, all three pigments stain the skin, and bilirubin tends to produce more "scleral" (conjunctival) pigmentation. The copper of Wilson disease does not pigment the sclera or the skin. The green Kayser–Fleischer ring is not to be confused with the brown limbal ring of Addison disease (Straub and Russman, 1966). This latter ring is more obvious at the superior and inferior arcs than it is medially and laterally.

Another key descriptor for the Kayser–Fleischer ring is "visible to the naked eye without the use of a slitlamp." It is true that patients with a wide variety of hepatic diseases, other than Wilson disease, apparently have a secondary abnormality of copper metabolism, which although different from that of Wilson disease eventually results in the deposition of enough copper in the Descemet membrane to be visualized by slitlamp examination (Rimola et al., 1978; Weinberg et al., 1981). Among these liver diseases are posthepatitic cirrhosis, primary biliary cirrhosis, cryptogenic cirrhosis, neonatal liver disease, active chronic hepatitis, and progressive intrahepatic cholestasis. In these cases, however, the green rings were reported only on slitlamp examination.

Alas, nothing is perfect. A truly green ring, visible to the naked eye, has been reported in one case of multiple myeloma associated with hypercupremia due to an unusual circulating copper–binding protein (Gordon et al., 1967). Also I have seen a tiny, thin, brownish-green ring, visible to the unaided eye, in a patient with Laënnec cirrhosis.

False Negatives

The recent claim that the Kayser–Fleischer ring is only 74% sensitive for the diagnosis is based on family populations with a mean age of 15 years and a range of 6 to 33 years (Nazer et al., 1986). In the older population, the Kayser–Fleischer ring is more confounded by false positives (*vide supra*) than false negatives, although one 58-year-old patient with neurologic impairment due to Wilson disease, yet no Kayser–Fleischer ring, has been reported (Ross et al., 1985). The sign disappears with treatment of the disease.

Infections

In trachoma, blindness results from corneal ulcers and scarring. Destruction of the conjunctival goblet cells and the lacrimal apparatus leads to xerosis (drying) of the cornea, which is also constantly abraded by the inturned eyelashes.

River blindness caused by the filarial nematode *Onchocerca volvulus* blinds up to 50% of the adults in hyperendemic areas through an inflammatory reaction that leads to corneal scarring. Currently, this disease is found principally in sub-Saharan Africa, with small foci in Central America, South America, and the Middle East (Congdon et al., 2003).

The Red Eye

The differential diagnosis of the red eye, outlined in Table 10.3, includes conjunctivitis, keratitis, iritis, and angle-closure glaucoma. (I am yet to see my first case of *acute* angle-closure glaucoma, despite dilating the pupils of nearly all comers.)

The chief historical clue is that true pain, as opposed to a scratchy discomfort, signifies iritis, not conjunctivitis. Pain and photophobia, usually without tenderness, are typical of keratitis. The painful, photophobic eye should be promptly referred to an ophthalmologist as visual loss is a major concern.

To help determine the cause of undiagnosed eye pain, Dr Gervais instills a drop of local anesthetic. If all pain vanishes, the cause is superficial (cactus barb, corneal abrasion from contact lens use, etc.) If the pain is not alleviated, a more serious intraocular cause, such as iritis or angle-closure glaucoma, must be considered.

The most discriminating physical finding is the distribution of the infected vessels. To see whether the involved vessels are the superficial conjunctival ones, check whether they move when you place your finger below the lower lid and press upward, as you did when testing for chemosis by displacing the conjunctiva.

Although posterior keratoprecipitates make the diagnosis of iritis (see the ophthalmoscopic examination, below), most patients with acute iritis do not yet have these at the time they initially present. Although pus makes the diagnosis of acute conjunctivitis, many cases of acute conjunctivitis have such watery secretions that you will not be able to tell whether pus is present. Gram and Wright stains of conjunctival scrapings are extremely useful in the diagnosis of the red eye. Viral (epidemic) conjunctivitis will frequently be associated with palpable preauricular lymph nodes (see Chapter 8).

When in doubt about the distinction between iritis and conjunctivitis, proceed to the Au–Henkind test (Au and Henkind, 1981). Ask the patient to close the eye to be tested, leaving the other eye open. Shine a penlight into the open eye and ask the patient whether he has experienced a sensation in the closed eye. Pain in the closed eye is a positive test for iritis. This test presumes that a normal consensual pupillary response to light is present. The test is 100% sensitive and highly specific.

Patients with iritis also experience pain during testing for accommodation, and the pain occurs at a reproducible distance. Thus, the examiner begins with the patient focusing on a distant (3 ft) finger as it moves closer to the eyes (Talbot, 1987). The sensitivity was 74%, the specificity 97%, and the positive predictive value 50% in an outpatient ophthalmology clinic, where the prevalence of the disease was 4.5% as judged from biomicroscopy.

A problem seen more often in real life than in books is the patient with *both* iritis and conjunctivitis. Thus, it is important to use more than one discriminator so as not to miss a diagnosis. When both are present, one should begin with the differential diagnosis of acute iritis because it includes more medically important and treatable entities than conjunctivitis, which itself can be secondary to iritis. (Iritis is almost never secondary to conjunctivitis, except in the case of infectious etiologies.)

About 53% of patients referred to an ophthalmology clinic for iritis had an associated systemic disease. The most common medical

TABLE **10.3** *Differential diagnosis of the red eye*

Descriptor	Acute conjunctivitis	Acute keratitis	Acute iritis	Acute angle-closure glaucoma
Onset	Gradual	Gradual	Gradual	Abrupt
Pain	No true pain; burning or itching	Pain, usually not tender	Moderate and noxious pain, may be likened to a headache	Severe
Injection	Most intense in fornices; opical epinephrine (1:1,000) lightens eye; superficial vessels move with conjunctiva; pinker	May have ciliary flush	More intense near limbus; individual vessels often not distinguished; less pink	As for iritis
Pupil	Normal	Normal	May be miotic with sluggish or absent reflexes	Somewhat dilated; does not respond to light
Cornea	Always clear	Check for abrasions, ulcerations, dendritic lesions	May have posterior surface keratoprecipitates or may be clear	Foggy; iris out of focus
Secretions	May have pus	Watery	Watery	Watery
Vision	Always normal	May be reduced	May be reduced	Markedly reduced
Associated findings	May have preauricular node	Photophobia	Photophobia; eyeball usually tender	Usually associated with nausea and vomiting; hard eyeball

From Newell F. *Ophthalmology: Principles and Concepts*. 8th Ed. St Louis: CV Mosby; 1982:559, with permission.

conditions were Reiter syndrome, ankylosing spondylitis, Sjögren syndrome, and sarcoidosis (Rosenbaum, 1989). Other associated conditions include systemic lupus erythematosus, Still syndrome, inflammatory bowel disease, HLA B27 positivity in and of itself, Behçet disease, polyarteritis, granulomatosis, and sarcoidosis.

The differential diagnosis of conjunctivitis includes Gram-positive cocci, Gram-negative cocci, Gram-negative rods, some chlamydiae, viruses, and allergies. Only Reiter syndrome, among the seronegative spondylarthropathies, is associated with conjunctivitis. A deficiency of pyridoxine (vitamin B_6) can be associated with conjunctivitis. Besides inadequate dietary intake, causes of this deficiency include inborn errors of pyridoxine metabolism, malabsorption syndromes (especially gluten-sensitive enteropathy), alcoholism, severe organ dysfunction (cirrhosis or uremia), and with drugs that act as vitamin B_6 antagonists. These include cycloserine, isoniazid, penicillamine, and oral contraceptives (Greenfield and Gregory, 1998).

The differential diagnosis of the red eye includes neurosurgical conditions. One patient with a dural (indirect) carotid-cavernous sinus fistula was treated for "chronic conjunctivitis" for 6 months. The arterialized conjunctival vessels should have been a clue. There may also be mild proptosis, minimal eyelid swelling, and chemosis. The index of suspicion is raised if increased intraocular pressure, mild headache, diplopia, or a bruit accompanies a chronically red eye (Biousse et al., 1998).

The Anterior Chamber

Introduction to Glaucoma

Glaucoma is a disease of intraocular (*not* arterial) hypertension, which insidiously produces irreversible blindness. Just as war is too important to be left to the generals, glaucoma is too important to be left to the ophthalmologists.

Glaucoma will not be diagnosed early by checking the visual acuity or by checking the visual fields by confrontation. It does not affect the ability to focus, and the early visual field cuts are usually nasal, where they are least likely to be detected by confrontation. (Later, the field cuts become nasal arcuate, and then they spread temporally; central vision is the last to be lost.) More than 50% of the nerve tissue may be lost before visual field changes can be detected. It is partly for these reasons that glaucoma is so pernicious and insidious.

Glaucomatous changes in the optic disc are discussed later in the chapter.

There are basically three forms of glaucoma (all of which eventually cause the same type of changes in the visual fields and optic discs): (a) wide-angle or open-angle (the most common), in which the depth of the anterior chamber is normal; (b) narrow-angle (rare), also called *acute-angle* (pupillary block) or *angle-closure glaucoma*, in which the anterior chamber is shallow; and (c) a miscellany including "normal-pressure" glaucoma.

"Normal-pressure" glaucoma is metaphysical. Just as there is no such thing as "the" blood pressure, there is no such thing as "the" intraocular pressure. If an individual has a high intraocular pressure at one point in time, but his pressures when actually measured at another time happen to be normal, then he might be said to have "normal-pressure" glaucoma, which may be likened to "labile hypertension."

Glaucoma may result from neovascularization on the iris, *rubeosis iridis*, secondary to ischemia. Ipsilateral carotid stenosis is one cause (Lawrence and Oderich, 2002).

Checking the Anterior Chamber Depth

Because dilating the pupil can acutely precipitate an attack of narrow-angle glaucoma (*vide infra*), it is essential to check the depth of the anterior chamber before instilling a mydriatic if one is concerned about narrow-angle glaucoma (Fig. 10-9).

A Method

1. Have the patient look forward at the examiner's eyes.
2. Aim the beam of a flashlight or a penlight from the temporal side at the patient's lateral limbus, in a plane perpendicular to the patient's axis of vision. The light should shine across the iris in a plane that just barely illuminates the entire iris. Anterior displacement of the lens and central iris forms a nipplelike protrusion that casts a medial (nasal) shadow (Fig. 10-10).

Another method of estimating the anterior chamber depth uses the slit aperture on the ophthalmoscope.

Positive Tests

Note that the check for a shallow anterior chamber tells you nothing about whether the patient might have glaucoma without a narrow angle. In fact, it does not really detect narrow-angle glaucoma but only the shallow anterior chamber that coexists with nearly all cases of narrow-angle glaucoma. Thus, about 90% of all positives will be false positives for the disease because the test picks up all cases of central shallowing of the anterior chamber, which is common in older persons with enlarged lenses. So, if the test is positive for a shallow anterior chamber, you *must* arrange for the intraocular pressure to be measured. If the pressure is normal, you may dilate the pupil. If the pressure is high, however, and the patient actually has narrow-angle glaucoma, he can be treated appropriately, with laser or surgical iridectomy, after which the pupil can be dilated with impunity.

Negative Tests

If the test is negative, I proceed to dilate the pupils. However, false negatives for narrow-angle glaucoma are very rare. Therefore, because an attack of narrow-angle glaucoma could come hours later, all patients should be cautioned to be alert to the development of pain or blurred vision and to call immediately should one of these supervene.

Because deep anterior chambers are the norm for myopes, their pupils can be safely dilated. Hyperopes, 55 years or older, should be dilated with caution because these patients tend to have shallow anterior chambers that predispose them, albeit rarely, to develop acute attacks of angle-closure glaucoma (R. Gervais, *personal communication*, 1998).

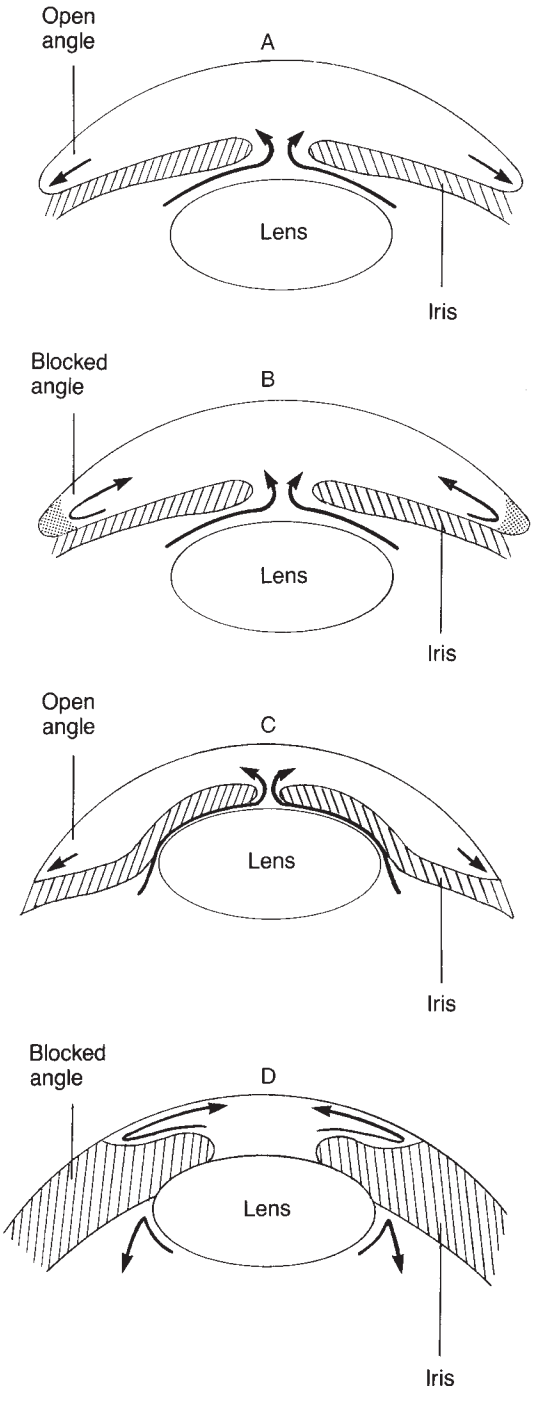


FIGURE 10-9 **A:** A normal eye, showing the flow of the aqueous into the anterior chamber and thence egressing through the canal of Schlemm in the angle. **B:** The common wide-angle or open-angle glaucoma showing the block at the egress from the anterior chamber. There is no anterior displacement of the lens and so the anterior chamber depth will be normal with this kind of glaucoma. **C:** Anterior displacement of the lens in senescence or in someone with a propensity for acute-angle glaucoma. **D:** Anterior displacement of the lens in someone developing an attack of acute-angle glaucoma following pupillary dilation. As the iris dilates, it occludes both the entrance of the fluid to the anterior chamber and its egress thence. As the fluid continues to form, the pressure can only rise. Compare with C.

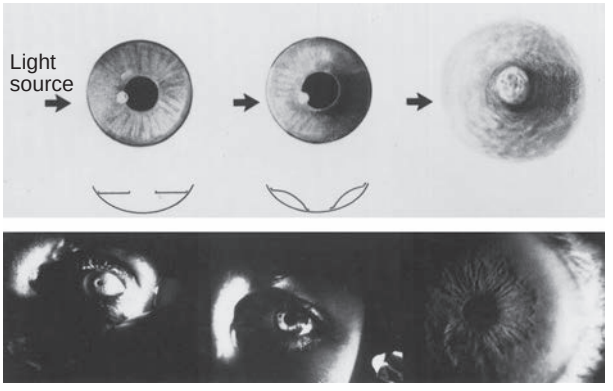


FIGURE 10-10 Method of checking the depth of the anterior chamber. In the top panel, a light source illuminates the iris from the temporal side. There is no shadow on the normal eye. The eye in the center demonstrates a positive test because of the anterior buckling of the lens and central iris (see the coronal section in the center of the **top** panel). On the right is a photograph of a nipple, for comparison. The **bottom** panel shows the following: left, a positive test on the left eye of a patient with untreated narrow-angle glaucoma; center, a negative test on a normal eye with a nevus on the nasal iris (not a shadow); right, a close-up of a positive test, provided by Dr Eugene De Juan, Jr of North Carolina. (From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30:1–64, with permission.)

To check for myopia, take the patient's glasses and look through them at the back of a chair or other object. If the object appears to move down as the glasses move down, the glasses belong to a myope. If the object moves in the opposite direction, the glasses belong to a hyperope. If you forget which direction is which, try the test first using your own glasses (if you are myopic) or those of another staff member.

An exception to the rule that patients with deep anterior chambers cannot get angle-closure glaucoma is the secondary angle closure arising from blockage of the ducts by neovascularization or cellular infiltrates. These blockages can occur in patients with advanced diabetic retinopathy, "strokes" in the eye called *branch vein occlusions*, or severe systemic vascular disease. Usually, the eye is already blind.

Screening for Glaucoma

Because the increase in intraocular pressure occurs long before the patient experiences any symptoms and because the disease is so eminently treatable, screening for glaucoma is important for preventive medicine. A 2-year study in which patients on a general medical service were screened by Schiotz tonometry (Fig. 10-11) revealed a 3.3% prevalence of glaucoma (Robertson, 1977).

Black patients are three to four times more likely to have open-angle glaucoma than whites (Congdon et al., 2003). The condition tends to be much more malignant and rapidly progressive in black patients and also more difficult to treat (R. Gervais, *personal communication*, 2004).

Estimating the Intraocular Pressure

A Method

1. Have the patient close his eyes lightly.
2. Rest your hand on the patient's forehead and lightly press on the eyeball through the relaxed lid with one or two fingers. How does it compare with your own? Is it soft, like a ripe grape, or hard, like an unstuffed green olive with the seed still in place? The latter is abnormal and suggests one of the three forms of glaucoma. The former is usually normal, although extreme softness can also be a sign of advanced volume depletion.
3. As with all paired organs, you must check both sides and compare them with each other. Some of the secondary forms of glaucoma may afflict only one eye.

FIGURE 10-11 Schiötz tonometer. The pressure in this hypertensive grape is 29 mm Hg, corresponding to the scale reading of 2, according to the chart that comes with the instrument. Normal intraocular pressure is 15.8 ± 2.5 mm Hg. (Photograph by Patti Wylie, with permission.)

Eyeball palpation is making a comeback in nursing homes, whose inhabitants may be unable to cooperate for tonometry. However, it is more often used to check for the soft eyeballs of dehydration than for the hard eyeballs of glaucoma. This estimate cannot be performed with confidence until one has accrued substantial experience, with feedback from actual tonometry readings.

Measuring the Intraocular Pressure

Because of insufficient accuracy, the Schiötz tonometer has generally been replaced by the (much more expensive) Tonopen, which also requires the user to get some training to obtain reproducible values. Ophthalmologists usually prefer the use of applanation tonometry. Every optometrist will have the equipment to measure pressure with an air puff tonometer, which does not require instillation of a local anesthetic.

If you do use a Schiötz tonometer, be sure to clean it thoroughly with alcohol or bleach after each use. It needs to be dismantled periodically both for cleaning and for ensuring that the plunger is moving freely. A little sterilizer, with a heating element and timer, was made for immersing the end of the tonometer (R. Schindler, *personal communication*, 2004).

A Pedagogic Note

Dr Andy Lonigro of Missouri was visiting his sister when his brother-in-law complained of "blind spots."

"Then you better go directly to the doctor. This needs to be checked immediately," advised Dr Lonigro.

"Oh, I did. The doctor told me it was my contact lenses and that I should stop wearing them for a while."

"I'd go see another doctor if I were you."

"Well, I did. And the second one told me the same thing."

"Look, you better go see an ophthalmologist."

"I did. They were both ophthalmologists."

"You mean optometrists?"

"No. They were both ophthalmologists, not optometrists."

Dr Lonigro arranged for his brother to be examined, and an intraocular pressure of 60 mm Hg was found (the upper limit of normal being 20 mm Hg).

This story illustrates two principles: (a) good medicine does not require a giant intellect, but it does require thoroughness; and (b) certificates on the wall do not make diagnoses, physicians do.

Acute Angle-closure Glaucoma

Patients have gone blind from acute angle-closure glaucoma while having a "neurosurgical massage" (MRI and/or CT scan) to work up an acute headache with or without nausea (R. Gervais, *personal communication*, 2004). A patient whose most prominent symptom was nausea underwent a complete gastrointestinal workup and was blind before anyone noticed her rock-hard eyeball (R. Schindler, *personal communication*, 2004).

Patients with acute-angle glaucoma feel very ill and may not be able to localize their pain to the eye; thus, a high index of suspicion is needed. While the signs are present, they may not be prominent enough to draw the attention of the physician who is not looking for them. The eye should be at least a little red, but may not be very red, and the cornea may appear a little smoky compared with the other side. The pupil on the affected side may be slightly larger and may show a diminished response to strong light. In the emergency room or other setting without a slitlamp, however, Dr Gervais pays little attention to pupillary signs in older patients (*vide infra*). Angle-closure glaucoma is usually unilateral; the difference in pressure between the two eyes should be obvious on palpation.

The Iris

Findings in the iris are often associated with pupillary findings (*vide infra*) because the function of the iris is to regulate pupillary size. The iris is part of the uvea or uveal tract, which is the vascular, pigmentary, or middle coat of the eye. The findings of anterior uveitis, or iritis, are described in the discussion on the red eye.

Spots on the Iris

Check the iris for nevi, which if elevated may actually be melanomas. Also, check for Koeppe nodules (which are most easily seen as projections into the pupil). These may be a clue to sarcoidosis, although they are also seen in tuberculosis and other uveitides.

Brushfield spots are white spots in the iris, which at one time were thought to be diagnostic of Down syndrome. Although they are indeed present in 85% to 90% of those so afflicted, they have also been found in 10% to 24% of normal subjects (Donaldson, 1961). The Brushfield spots in Down syndrome are more numerous than in normal individuals. (Normals have about 11, patients with Down syndrome have about twice as many.) A normal subject's spots tend to be in the periphery, whereas at least some of the spots tend to be located in the middle third of the iris in patients with Down syndrome. The spots are more distinct in patients with Down syndrome. Finally, the spots are associated with hypoplasia of the iris in 50% to 95% of patients with Down syndrome, whereas only 9% of normals have this hypoplasia. The hypoplasia may be detected by searching the periphery of the iris for a tangential missing piece (Donaldson, 1961).

A Note on Nomenclature. The old term *mongolism* was offensive alike to whites with the disease and to Asians without it. The eponym is preferred to "trisomy 21" because a small percentage of cases have translocations rather than an extra chromosome.

Multiple Lisch nodules, yellow-brown hamartomas about 1 mm in diameter within the iris, develop by the age of 29 in about half of patients with neurofibromatosis type 1 (Karnes, 1998). They are best seen with a slitlamp but may also be seen with a magnifying glass or the direct ophthalmoscope; try a plus 20 setting (Kaye, 1998).

Pupils

> *In the middle of the eye there is a hole which constricts with strong light and dilates with darkness.*
>
> —Rhazes, 850 to 932

Measuring Pupil Size

Pupil size should either be measured accurately or not at all. If measurements are not made, one is restricted to describing the pupils as widely dilated, midposition, or pinpoint. These descriptions are far too vague to be used as baseline points when attempting to assess changes over time or differences between the two pupils. (The descriptor "pinpoint" pupils tend to be used inaccurately for anything less than 2.5 mm. True pinpoint pupils are very rare, even in an overdose of a narcotic analgesic.)

A Method

1. Photocopy Fig. 10-12 and tape it to a piece of cardboard. As some photocopy machines will change the scale a little bit, you should measure the size of the dots. (However, as you are usually interested only in differences, repeated use of the same inaccurate card will give precise[3] measurements.)

[3] As in physics, precision is defined by reproducibility, and accuracy by reference to an external standard.

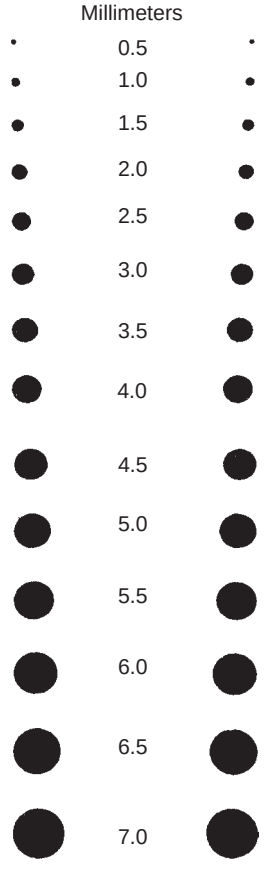


FIGURE 10-12 Card pupillometer. See text for instructions for use.

2. Hold the card next to the patient's iris, and move it up and down until the patient's pupil matches a black spot of the same size. With practice, you will easily be able to appreciate the 0.5-mm gradations. For comparisons to be meaningful, measurements must be made in the same amount of ambient light and with the same accommodation distance.

A pupillary dilatation of as little as 0.5 mm in response to an injection of a narcotic antagonist, such as naloxone, has been used as a legal definition of addiction in some states (Sapira and Cherubin, 1975). Pupil dilation from baseline can similarly be sought, for medical purposes, as evidence for precipitated abstinence when a patient is given naloxone in the emergency room.

Anisocoria

"Anisocoria" simply means inequality of the pupils. In addition to the "benign" and factitious causes given in Table 10.4, up to 20% of normal persons will have anisocoria (pupillary inequality = 0.4 mm in *dim* light) at any given point in time (Lam et al., 1987).

If one requires that the pupillary inequality be 0.5 mm or more in bright light and that it be present more than once, there will be few cases of benign causes and relatively more bona fide cases detected. In long practice, one will even see cases of bona fide anisocoria that last for days to weeks and then disappear. These benign cases do not have associated neurologic signs although they may produce anxiety when they occur among the neuroanatomically sophisticated. The best treatment is to be sent to a very old clinician.

Horner Syndrome

Horner syndrome consists of anisocoria (the smaller pupil homolateral to the lesion) plus unilateral (homolateral) enophthalmos, ptosis, anhidrosis, and decreased pilomotor response (Table 10.5; also see Chapter 26.)

A tumor in the superior sulcus (Pancoast syndrome) can produce Horner syndrome (most frequently on the left), in association with neurologic manifestations in the homolateral arm. The latter consist of sensory changes (paresthesia, hypesthesia, hyperesthesia, thermoanesthesia); autonomic changes (anhidrosis, decreased piloerection, warmth, digital dystrophy, and dependent cyanosis); motor changes, including fibrillations, fasciculation, and pseudoulnar signs (inability to oppose the thumb and little finger, with interosseus atrophy); and other muscle atrophy and weakness.

Pancoast (1932) was not the man who discovered the syndrome that bears his name but the one who popularized it. The first case (Freeman, 1921) was described 3 years before Pancoast wrote his first paper (Pancoast, 1924). Most ironically, Pancoast was the radiologic consultant to that first case and missed the diagnosis both prospectively and retrospectively!

Table 10.4 is a modified differential diagnosis of the type described in Chapter 27. The entities are grouped under the processes that one might have originally encountered in pathology. Tables 10.4 and 10.5 illustrate another principle discussed in that chapter: the concept of levels. Once one has decided that the etiology of anisocoria is Horner syndrome, one is then obligated to perform in turn the differential diagnosis of the latter. If one then diagnoses Pancoast syndrome as the cause of Horner, one might proceed even further to determine what type of superior sulcus tumor was involved.

Pupillary Shape

The acronym PERRLA, found in the records of a bygone day, meant that the *p*upils had been examined for *e*quality of size, *r*egularity (or *r*oundness of shape), *r*eactivity to *l*ight, and *a*ccommodation. Abnormalities of shape are listed in Table 10.6; the important ones are set in boldface type.

Pupillary Responses

Pupillary Response to Light (Reaction)

The pupillary response to light is generally easy to test; it just involves shining a penlight into the patient's eyes. Check both the direct and the consensual response. (The consensual response is the constriction induced by shining the light in the opposite pupil.) On the routine examination, if both pupils react directly, a consensual response to light need only be observed in one pupil.

In patients with dark brown eyes, it may be difficult, in a dimly lit room, to discern the difference between the pupil and the iris.

A Method

To get around this problem, illuminate the pupils stroboscopically at the rate of twice per second.

1. Stare at where the pupil will be and quickly sweep the penlight beam over the patient's eye while attending to the briefly illuminated pupil size.

TABLE **10.4** *Differential diagnosis of anisocoria*

Condition	The abnormal pupil is the one that is relatively Dilated	Constricted
Factitious and benign	Mydriatic in one eye Unilateral blindness Prosthetic eye Unequal lighting Ipsilateral, unilateral cataract	Miotic in one eye Prosthetic eye Unequal lighting
Mechanical	Iris diseases, trauma, or aniridia Unilateral narrow-angle glaucoma	Posterior synechiae
Inflammatory	Uveitis	Uveitis Keratitis Tabes dorsalis
Vascular	Internal carotid insufficiency (or other anterior ocular segment ischemia) Aneurysm Carotid sinus thrombosis Subdural hematoma Epidural hematoma	
Neurologic	Pupillary sphincter paralysis Encephalitis Neoplasms Other cerebral condition Infections Botulism Diphtheria Herpes zoster Syphilis Toxic Alcohol Lead Arsenic Others Diabetes	Midbrain lesion Horner syndrome (Table 10.5)

From Newell F. *Ophthalmology: Principles and Concepts*. 8th Ed. St Louis: CV Mosby; 1982:559, and Roy FH. *Ocular Differential Diagnosis*. 3rd Ed. Philadelphia, PA: Lea & Febiger; 1984, with permission.

2. On the first sweep, you will actually see the pupil before a response to the light, and on the second sweep, the normally reacting pupil will be smaller. (It is easier to see it this way because if the light is maintained on the pupil the examiner must try to remember the original size of the pupil while watching it constrict.)

Sometimes it is easier to see the pupil dilate after the light is removed than to see it constrict.

The consensual reflex can be tested in a similar manner:

1. Sweep past the test eye quickly for a baseline observation.
2. Shine the beam into the opposite eye for a ½ second (though not looking at *its* pupil but rather keeping the baseline pupil in eye and in mind).
3. Sweep the light back to the test eye to see whether constriction has taken place.

Self-test. To be sure you understand this section, do the self-test shown in Fig. 10-13.

Marcus Gunn Pupil

If the pupil of the test eye dilates when the penlight shines on it in step 3, then the consensual light reflex is more pronounced than the direct reflex. The patient is said to have a Marcus Gunn pupil or a positive "swinging flashlight test."

This apparently paradoxical reaction to light is really because the affected side has an intact motor system but a defective sensory

TABLE **10.5** *Differential diagnosis of Horner syndrome*

Congenital
Demyelinating disease
- Multiple sclerosis
- Other

Mechanical
- Syringomyelia
- Trauma
- Thyroid adenoma
- Mediastinal tumors

Vascular
- Posterior inferior cerebellar artery syndrome
- Internal carotid artery aneurysm

Neoplastic
- Brainstem tumor
- Cervical cord tumor
- Neurofibromatosis
- Part of Pancoast syndrome

From Newell F. *Ophthalmology: Principles and Concepts*. 8th Ed. St Louis: CV Mosby; 1982:559, and Roy FH. *Ocular Differential Diagnosis*. 3rd Ed. Philadelphia, PA: Lea & Febiger; 1984, with permission.

TABLE **10.6** *Abnormalities of pupillary shape*

Shape	Etiology
Oval	**Neurosyphilis**
	Glaucoma (dilated)
	Congenital corectopia (eccentric)
	Adie pupil (dilated)
Pear-shaped	Postsurgery
	Old anterior synechiae
	Congenital coloboma
	Neurologic disease
Scalloped	Rupture of the sphincter muscle
	Amyloidosis
Polygonal	**Neurosyphilis**
Other irregularity	Argyll Robertson pupil
	Posterior synechiae, especially after prior uveitis

From Roy FH. *Ocular Differential Diagnosis*. Philadelphia, PA: Lea & Febiger; 1972, with permission.

system (i.e., there is an afferent pupillary defect in the eye that dilates with direct illumination [Miller, 1985]). The affected eye's normal efferent response is seen with the light shining on the contralateral eye. (The sign can also be elicited by covering the normal side.)

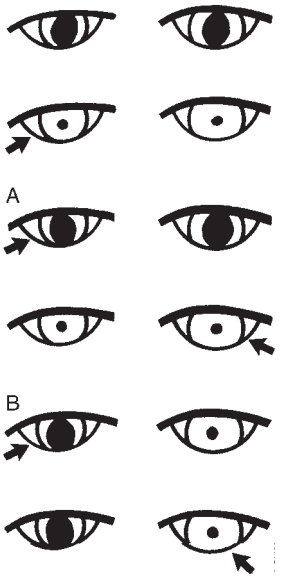


FIGURE **10-13** In all the panels, the patient is looking at you. The top pair of eyes illustrates the baseline. The second pair of eyes shows the normal response. In all panels, the *arrow* indicates from which side the light is being shone. Write down your diagnoses for the conditions illustrated in situations **A** and **B** (answers in Appendix 10.1).

Dr Gervais also asks the patient to tell him whether a bright light source is much brighter in one eye compared with the other. This subjective test correlates very well with the swinging flashlight test.

The Marcus Gunn pupil is seen in any unilateral disease of the retina or optic nerve (e.g., retrobulbar optic neuritis or ipsilateral monocular blindness).

Pupillary Accommodation

To test for pupillary accommodation, have the patient look at something a long distance away and then focus on something just in front of his eyes, such as your finger or a pencil. Constriction is the normal response to the near object. Another test is to ask patients under the age of 45 to read print with their glasses on. To see the importance of accommodation, students can dilate one of their pupils with tropicamide, put their glasses on, and attempt to read print, comparing one eye with the other.

Importance of Pupillary Responses

We check the pupillary responses because the loss of accommodation, reaction to light, or consensual reaction is indicative of ocular or nervous system disease (Table 10.7). The converse can also be helpful. If a patient has total loss of vision in both eyes, the pupillary reactions to light should be appropriately missing (see the section on ocular malingering or hysteria). However, one should not be too quick to diagnose ocular malingering. I was once presented a patient who claimed adult-onset total blindness but in whom the pupillary direct and consensual responses to light were both well preserved. The house officer had failed to examine the fundi. The patient had bilateral macular degeneration and was for all intents and purposes legally blind, but the surrounding retinal tissues were normal, accounting for the normal light reflexes.

TABLE **10.7** *Abnormal pupils*

Name	Size/shape	Accommodation	Reaction	Laterality	Comments
Argyll Robertson	Usually miotic; possibly irregular	Normal	Absent (late); sluggish (early)	95% bilateral	Formerly usually CNS lues (see also Table 10.8); incomplete dilation with atropine
Adie tonic pupil	Not always miotic	Absent or sluggish	Absent or sluggish	80% unilateral	Never CNS lues; tendon jerks may be absent; methacholine constricts; normal response to mydriatics
Fixed		Absent	Absent	Unilateral or bilateral	Meningovascular syphilis or blindness
Paradoxical			Dilates		Seen in CNS lues, tumors, and "normals"
Paradoxical		Dilates	Normal		Same as above
Horner syndrome	Miotic			Unilateral	Seen in Pancoast syndrome, *inter alia*
Parinaud	Never miotic	Variable	Sluggish	99% bilateral	Never benign; seen with Parinaud syndrome

From Duke-Elder S, Scott GI. Neuro-ophthalmology: XII. In: Duke-Elder S. ed. *System of Ophthalmology*. St Louis: CV Mosby; 1971 and Maciewicz RJ. Case records of the Massachusetts General Hospital. *N Engl J Med*. 1983;309:542–549, with permission.

Fixed, dilated pupils are a well-known sign of brainstem disease. Less well known are the fixed pupils that fail to dilate in the dark. These are also an ominous indicator of brainstem disease (*vide infra*). In increased intracranial pressure, there is a loss of hippus (the 1-per-second pupillary dilation–constriction sequence), even before the gross light response is lost.

Pupils in Comatose Patients

Pupillary abnormalities in comatose patients (Plum and Posner, 1972) may be of localizing and prognostic value. Drug effects and preexisting conditions such as those listed in Table 10.7 also need to be considered. Examine the pupillary reflex with a bright light; a magnifying glass may show a reflex constriction not visible to the naked eye.

Also, check for Horner syndrome. The anhidrosis associated with hypothalamic lesions involves the entire ipsilateral half of the body, not just the face, neck, and arm as in cervical sympathetic lesions. The importance of recognizing this hypothalamic sign is that it may be the first clear sign of incipient transtentorial herniation.

The pupils are midposition or large (5 to 6 mm) in tectal lesions; they are fixed to light but may show hippus or spontaneous variations in size. In third-nerve lesions due to uncal herniation, one pupil is fixed and dilated. In midbrain lesions, the pupils are midposition and fixed. In pontine hemorrhage, the pupils are pinpoint although a light reflex may be seen with a magnifying glass. In metabolic coma, the pupils are small, but the light reflex is preserved until the terminal stages, with the important exception of barbiturate intoxication, in which the pupil may be fixed. In severe anoxic damage, the pupils become fixed and dilated. If the dilation persists longer than a few minutes, brain damage is severe, although younger patients have recovered even after the pupils have been fixed and dilated for hours. Hypothermia can also fix the pupils.

Full details on examining the comatose patient are beyond the scope of this text, which can only hint at the complexities (Plum and Posner, 1982).

Examination of the pupils is an essential part of the evaluation for brain death (see Chapter 26).

Argyll Robertson Pupil

The Argyll Robertson pupil has been likened to a prostitute: it accommodates but does not react. The Argyll Robertson pupil is never benign. It is seen in central nervous system (CNS) syphilis and in other conditions (Table 10.8). For the purpose of winning coffee money from those who believe there was a Dr. Argyll, the full name of the one physician who is commemorated in the Argyll Robertson pupil is Douglas Moray Cooper Lamb Argyll Robertson. A more complete description than the one in Table 10.7 was given in his case reports (Robertson, 1869a,b). An even better explication of the Argyll Robertson pupil was made by Adie (who has a different pupil named for him).

1. The retina is quite sensitive, that is, the vision is intact. This is important because the pupil of the blind eye in many unilaterally blind patients accommodates but does not react to light; that alone does not make it an Argyll Robertson pupil. The pupil of a blind eye may react consensually, whereas the true Argyll Robertson pupil never does (Adie, 1931b). Similarly, if the vision is defective from some cause other than retinal disease, some reaction to light will persist as long as any vision remains. Such pupils react sluggishly to light but well to convergence (accommodation). However, this should *not* be called "incomplete" Argyll Robertson pupil, for the blindness and pupillary changes in this situation have nothing to do with CNS syphilis.

TABLE **10.8** *Other causes of Argyll Robertson pupils*

Tumors
Mesencephalic location
Craniopharyngioma
Infections and inflammation
Encephalitis lethargica
Polio encephalitis
Cerebral malaria
Herpes zoster
Lyme disease
Metabolic causes
Diabetes mellitus
Alcoholism
Carbon disulfide poisoning
Other
Syringomyelia
Pressure on cranial nerve III trunk by cerebral aneurysm
Trauma
Multiple sclerosis
Hypertropic interstitial neuritis
Charcot–Marie–Tooth disease
Sarcoid
Hemorrhage in the periaqueductal gray rostral to the Edinger–Westphal nucleus

From Duke-Elder S, Scott GI. Neuro-ophthalmology: XII. In: Duke-Elder S. ed. *System of Ophthalmology*. St Louis: CV Mosby; 1971 and Dasco CC, Bortz DL. Significance of the Argyll Robertson pupil in clinical medicine. *Am J Med*. 1989;86:199–202, with permission.

2. The Argyll Robertson pupil contracts briskly during accommodation and dilates, again briskly, if the subject again looks far away.
3. Alteration in the amount of light admitted to the eye does not influence the size of the pupil. Therefore, the Argyll Robertson pupil is fixed, not in the sense that it exhibits pupil atonia but in that it can remain the same size for days, weeks, or months.
4. Slow and only partial dilation occurs with the application of mydriatics.

Adie Pupil

The tonic pupil, or Adie pupil, may be described as the stereotypical bored housewife: it may neither react nor accommodate, or it may react only after a great deal of preparation in a dark room; in any case, it will be sluggish. The Adie pupil is always benign, unless the physician cannot make the diagnosis and erroneously diagnoses syphilis. To continue the mnemonic, one would expect to find more syphilis in prostitutes than in housewives.

Adie pupil was originally described by a number of other people, but we credit Adie for bringing these descriptions together (Adie, 1931a). In the initial six cases, the pupils were said to "react on accommodation but not to light." As ankle jerks and knee jerks were missing in most of the original cases, it was thought that these patients might be syphilitic, a fear that was disproved by testing. A few months later, Adie had correctly refined his pupil description as follows (Adie, 1931b):

1. The myotonic pupil is most often unilateral; it is then almost always larger than its mate.
2. It may be oval, with the long axis either horizontal or vertical.
3. It is often large, occasionally small, but never miotic.
4. When ordinary bedside methods are used, the reaction to light, direct and consensual, appears to be completely or almost completely abolished. However, after a sojourn in a dark room, the pupil dilates and, on reexposure to strong daylight, contracts very slowly. The emphasis is on a long exposure to diffuse strong daylight after proper preparation in a dark room.
5. During the act of accommodation for a near object (convergence), the pupil after a short delay will begin to contract very slowly but through a range in excess of normal. This originally larger (abnormal) pupil could thus end up smaller than the normal pupil on the opposite side! With convergence, the abnormal pupil might remain small for seconds to minutes after convergence has ceased.
6. However, prompt and full dilation occurs with those mydriatics (cocaine and atropine) that are so stunted in their effect on the Argyll Robertson pupil.

An odd additional finding has been rediscovered regarding the Adie pupil. In every Adie pupil that has any remaining light reaction, a segmental palsy of the iris sphincter will be found. This is characteristic of Adie pupil, although not pathognomonic because it can also be seen in traumatic iridoplegia, postganglionic denervation, preganglionic third-nerve diseases, aberrant regeneration of the third nerve, midbrain ocular motor involvement, and Parinaud syndrome if that occurs after trauma (Thompson, 1978).

Other Abnormal Pupils

Sluggish responses to light and accommodation are sometimes seen in myotonic dystrophy (Duke-Elder and Scott, 1971).

Among the British who were caught in the fall of Singapore and interned during World War II, Wernicke encephalopathy was said to produce the loss of accommodation, with a normal light response. This would be the reverse of an Argyll Robertson pupil.

A Caveat Concerning the Pupils of Older Patients

Very often, the pupillary sphincter is damaged during cataract or other intraocular surgery so that neurologic diagnoses cannot be made with any degree of certainty. Signs of such surgery may not be evident even to an ophthalmologist, and the history may be unreliable. Even without surgery, the pupillary responses of older patients become sluggish (R. Gervais, *personal communication*, 2004).

Ophthalmoscopic Examination

Much of the following discussion of the ophthalmoscopic examination may be found in Sapira (1984).

History

In 1847, Babbage, an eccentric British millionaire, had one of his engineers construct a device consisting of a silvered surface (a mirror) that reflected light into the eye. A scratch in the silvered

surface permitted one to peek for the first time into the illuminated interior of the living eye. Babbage gave the device to his personal physician who never realized its utility, apparently because Babbage was a known practical joker and because the physician, who was myopic, found that Babbage's device, lacking a lens system, did not work for him. Three years later, apparently independently, Helmholtz used the same principles, added a lens system, and published his invention. The ophthalmoscope used today is basically the same as that of Helmholtz, except that the light source is battery operated and the lens system is mounted on a wheel, which permits rapid focusing.

For about twice the price of the regular ophthalmoscope, the type generally found in clinics, one can purchase a Welch Allyn PanOptic ophthalmoscope, which has a wider field and greater magnification and enables examiner to use one eye to examine both of the patient's eyes.

Method

Parts of the Ophthalmoscope

Before attempting to look through the ophthalmoscope, it is a good idea to learn its components. First, switch on the light. If your ophthalmoscope has a rheostat, push in the button that unlocks the rheostat and rotate it to maximum brightness. Smaller ophthalmoscopes simply have an on–off switch.

If you are holding the instrument properly (with the diopter numbers pointing toward you and the light shining *away* from you), you will be able to shine the light on your palm. If you move the aperture selector dial, which usually lies between the lens wheel and the on–off rheostat, you can observe various shapes and colors of light. Under normal circumstances, you will use the round circle of white light. Some ophthalmoscopes have a second smaller circle, which decreases the amount of light. This may be used to decrease the amount of reflex pupillary constriction in the unusual circumstance that the pupils have not been pharmacologically dilated. Sometimes it is also useful to decrease reflected glare from the cornea and anterior lens. Some older ophthalmoscopes had an aperture that produced a half-moon of light that could be used for the same purpose. The best device to reduce glare, however, is a little window of polarizing glass, mounted on the part of the ophthalmoscope head facing the patient, which can be slid into place with a flick of the finger. (Some students do not even realize that their ophthalmoscopes are so equipped.)

The grids are intended for localization but are rarely used because of the common custom of describing lesions in terms of distance from the disc along radial coordinates (e.g., "1/2 disc diameters out at 8 o'clock," "3 disc diameters at 12 o'clock," etc.). Lesions may also be located in terms of their relationship to specific retinal vessels and their branchings, and in some cases, a drawing in the chart is used.

Most ophthalmoscopes also have a bluish green filter that provides "red-free" light. (This is *not* the lens used in fluorescein angiography, a special procedure performed only by those trained in its use. Specifically, one should *never* try to improvise any fluorescein examination of the eye that involves shining an ultraviolet light into the eye because this could cause blindness.) Some experts can make judgments about retinal arteriolar medial and adventitial thickening by using the red-free light. It has also been stated that red-free light is helpful in finding hemorrhages, which will appear black on a green field. However, hemorrhages generally appear dark red on a light orange field and are easy to see in any case. Missed hemorrhages result from a failure to look systematically, not from the color of the light.

Red-free light is also said to be useful for identifying early neovascularization (fine vessels) in patients with diabetes mellitus because it changes the red-on-orange contrast to black-on-green. Some skilled workers are also able to make estimates about damage to the outer nerve fiber layer on the basis of inspections with the red-free light. Other uses of red-free light are discussed later in the chapter.

Finally, there is an aperture that casts the light as a slit. This aperture provides a means for determining fundal contour and for estimating the depth of the anterior chamber. This is not the light used in a slitlamp examination. That is a special instrument used by ophthalmologists for studying the lens, Descemet membrane, and other anterior structures.

It is often very difficult to use the slit aperture for determining the contour of the optic disc because if one looks at the stripe directly *en face* monocular vision may not permit the appreciation of any contour. Sometimes one can move one's eye laterally, still peering through the viewing area, and so create an angle between the axis of inspection and the axis of illumination. The most frequent reason for wanting a measure of elevation is in the question of a "choked disc," or papilledema. For this purpose, however, using the slit aperture is inferior to measuring the elevation of the disc in diopters, which is a useful way to follow the progress of papilledema (or its resolution with treatment) on a day-to-day basis. This requires focusing on the disc with the ophthalmoscope, rather than with your eye (*vide infra*).

The other dial on the ophthalmoscope is used for changing the lenses, from high positive (magnifying), usually numbered in black, to high negative, usually numbered in red.

For the Attending. Some persons can do much of the focusing with the lens in their own eye, but use of the focusing wheel should be encouraged. The autofocusing ability is one more thing for the student to have to master initially, and it will eventually be lost with age.

Finally, when you have finished using your ophthalmoscope, do not forget to switch it off. In the case of an ophthalmoscope with a rheostat, you must rotate the dial to the point at which you hear or feel a click. Otherwise your batteries will often be drained, producing a light that is too dim. Although the rheostat, like the smaller peephole, is advertised as a method of decreasing the light for sensitive patients, it is just one more thing that can break, and it increases the cost of the instrument. I do not remember when I last tried to use mine, probably before I finally learned that one sees best with a bright light and that most compromises in clinical examination are to be eschewed.

Practicing with the Ophthalmoscope

Instruct your partner to remove his glasses and to stare at a fixed distant point. Remove your own glasses and select the round circle of white light. (You may wish to examine the patient through his glasses if he wears a highly "minus" set of lenses. Likewise, if either member of the doctor–patient dyad has a distorting abnormality of

the lens, such as a severe astigmatism, leave the glasses on for the examination that involves the abnormal eye.)

For the Older, Presbyopic Physician. Bifocals are an especially difficult problem for physicians with severe astigmatism. The near lenses cannot be used because of the angle, but taking the glasses off leaves the astigmatism uncorrected. If you anticipate this problem, save your last pair of glasses before getting the bifocals and try using them only during ophthalmoscopy.

To examine your partner's right eye, place the ophthalmoscope as close as possible to your own right eye, peer through the hole, and shine the light into your partner's right pupil until you see the red reflex. Repeat, using your left eye to observe the red reflex in your partner's left eye. It is very important to learn to use the correct eye (i.e., both of your eyes), even if you have a strong monocular dominance. Otherwise, you will have to hang over the top of the patient's head to examine one of his eyes, a contortion not always permitted by the clinical situation or the hospital architecture.

Holding a direct ophthalmoscope a few feet away from an eye with a dilated pupil to elicit a red reflex is itself a good examination technique. A poor red reflex associated with poor vision means a major problem exists: a dense corneal scar, dense anterior chamber hemorrhage, dense cataract, dense vitreous hemorrhage, and so forth. If the pathology is in an early stage, a normal red reflex can be elicited (R. Gervais, *personal communication*, 1998).

Checking the red reflex is the cornerstone of screening for retinoblastoma in young children. The red reflex becomes white in 60% of cases (Essman and Essman, 1992).

For the next step, it is best to use a teaching device such as an artificial eye or mannequin. If your school does not have such a device, volunteers should be solicited from the Curriculum Committee. In either case, begin examining the dummy by finding the red reflex as before. Next, move as close to the eye as you can, all the while keeping the red reflex in view through the ophthalmoscope. Turn the lens wheel until detail begins to appear. If you go too far, back up by reversing the lens wheel, just as you would with a microscope.

Looking into the eye with an ophthalmoscope is, in fact, looking through an in vivo microscope. (The optic disc is in reality only 1.5 mm in diameter, although it appears larger through the ophthalmoscope. The relative sizes of other structures and lesions are given in Table 10.9.) The main difference is that the traditional microscope focuses continuously and the ophthalmoscope lens wheel discontinuously. Similarly, when you first looked through a microscope, you learned, perhaps unconsciously, to relax your eye so as to look *through* the lens toward a point beyond it, rather than accommodating so as to look *at* the lens as if it were a small television set. Now, in using the ophthalmoscope, also allow your eye to adjust grossly to the different focal length needed to approach the fundus. Do not look at the lens, look *through* it. Then, perform the fine-focus adjustment with the focusing wheel on the instrument. (Some persons like to shift their own viewpoint slightly during the procedure. If they then see something red flash by, they know it is a blood vessel, and this gives them a target to focus on.)

Once you are able to focus on structures of the fundus, return to your partner. (Later you should go back to the mannequin to practice examining the four vascular axes, as described below.)

TABLE **10.9** *Size of various structures and lesions in the fundus oculi*

Structure or lesion	Size, in mm (μm)
Optic disc	1.5
Width of the arterial blood column exiting the disc	0.1 (100)
Average microaneurysm	0.05 (50)
Average drusen[a]	0.01 (10)

[a]Drusen can go to 100 μm and beyond.

When you are first practicing, and only then, you may omit the examination of the cornea and the lens. Your partner is presumably a healthy, young person with no opacities there. Just find the red reflex and focus in.

Some hints include the following:

1. You should be cheek by jowl with your partner. You must be as close as possible, as if looking through a keyhole or a window.
2. You may want to hold your partner's head from behind with your left hand.
3. Are you in a comfortable position? If your partner is sitting and you are standing crouched over him, you are learning a habit that will give you low back strain in later years. Worse, it is hard to concentrate on the examination if you are also concentrating on keeping your balance.
4. The subject needs a fixed object to look at with his unobstructed eye. With children, you may want to have a partner hold a toy for the child to look at, moving it around slowly while you focus in one direction.
5. Keep a panoramic view of the normal fundus in your mind's eye. The direct ophthalmoscope gives such a magnified, limited view that it is difficult for the student to keep the anatomy in perspective: the straight nasal vessels, the curving superior and inferior arcades of the temporal vessels avoiding the macula, and so forth.

For the Attending. In yesteryears, one of the better institutions had little penciled "x's" marked on the ceilings of rooms where generations of house staff had examined the fundi. Once, in a new institution, the department chairman instructed the house staff not to so mark the ceilings because the cost of painting them was allegedly causing the hospital to run a deficit. Later, I cared for a patient whose proliferative diabetic retinopathy had become irreversible under that chairman's "tight," nonophthalmoscopic control.

I always attempted to examine the fundi at least once when I was a visiting professor. I would ask someone to hold up a finger for the patient to look at. If, after a few seconds, the patient's eye began to wander, I checked to see whether the host's finger was still in place. When it was not, I knew that the fundi were examined so infrequently that the average participant in rounds did not even understand the need for a fixed point of gaze. This occurred much more often than accrediting agencies lead one to believe.

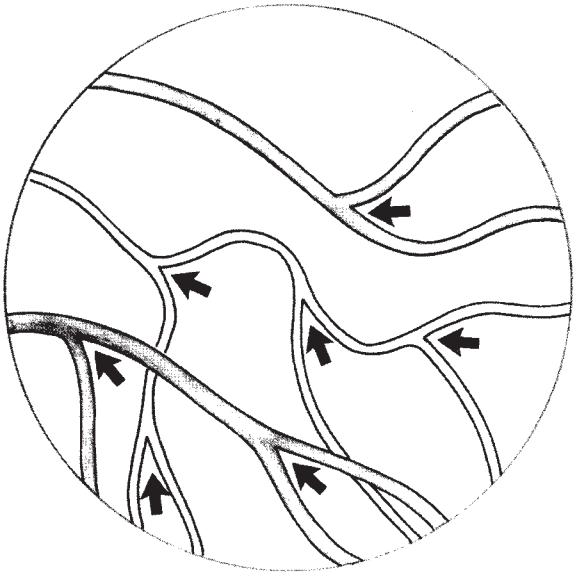


FIGURE 10-14 A law of nature: the bifurcations of the blood vessels always form arrows that point to the optic disc. (From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30:1–64, with permission.)

Once you have focused on a vessel, follow the natural arrows formed by the branchings of the blood vessels to find the disc (Fig. 10-14). Then, follow the vessels away from the disc in this sequence, returning to the disc each time: superior temporal vessels, superior nasal vessels, inferior nasal vessels, and inferior temporal vessels. (If you are unable to do this with your partner, you need more practice on the mannequin.) Then, without leaving the view, see whether you can change the aperture, finding the control wheel with your finger without looking at it. (Most people have to practice this on the mannequin also.) Repeat the procedure with your left eye, examining your partner's left eye.

It is very important to establish, from the beginning, a methodical sequence of examination, which you adhere to as rigidly and thoroughly as possible. Once you have practiced finding the disc and following the blood vessels, you can begin using the entire routine.

Dilating the Pupil

An illustration of how I made myself look stupid by not dilating the pupils is given later in the chapter (also see Appendix 10.3).

Contraindications

There are a few contraindications to dilating the pupils.

1. The most important one is the presence or suspicion of a cerebrovascular or other neurologic disease in which evolving pupillary signs might be of diagnostic value. (Remember that the effects of the medication may persist for a variable length of time and that asymmetry of the pupils may result, even if you are careful to put the same number of drops in each eye.)
2. Certain lens implants are an absolute contraindication to pupillary dilation.
3. Anterior uveitis is a *relative* contraindication.
4. As mentioned above, if the patient has *narrow-angle* glaucoma, dilating the pupil could precipitate an acute attack. If this results in an earlier diagnosis of the problem, the patient might ultimately benefit, provided that the physician is capable of recognizing and treating it.

A Method

Practice first on yourself and your partner.

1. Be sure that your black bag is supplied with a mydriatic agent. I have used 10% phenylephrine (Neosynephrine ophthalmic) for 30 years without difficulty. However, if I were starting over today, I might choose tropicamide 0.5% or 1% (Mydriacyl ophthalmic) instead.

   There is no doubt that these medications are absorbed systemically. Because much of the absorption seems to be via the nasal mucosa (as a result of tearing, with passage of the drug through the nasolacrimal duct), the problem of absorption can be minimized by having the patient press on the inner canthi to block the ducts for a few minutes after instillation.

   Phenylephrine, an alpha-1 adrenergic agonist, has been associated with hypertension, presumably causing an intracerebral hemorrhage in one adult case (Adler et al., 1982). The ocular effects can be reversed with thymoxamine (if you live where it is available) or any other ophthalmic alpha-blocker. You could use phentolamine or prazosin as specifics to reverse systemic effects, but in most cases, one would simply let the drug wear off.

   Tropicamide, a very short-acting antimuscarinic agent, might be preferable for a patient whose cardiovascular reactions you are worried about. However, it occasionally fails to produce a brisk pupillary dilation. In one instance, it caused a systemic reaction of opisthotonos, pallor, and cyanosis in a child, presumably because of anaphylaxis (Wahl, 1969). The ocular effects can be reversed with pilocarpine ophthalmic solution.

   Dr Gervais uses a drop of Fluoress (fluorescein plus a local anesthetic) first to numb the eye, followed by a drop of tropicamide and then a drop of neosynephrine. The last two drops cause stinging.
2. With the patient seated, have him maximally extend his head on his neck and instruct him to stare at the ceiling. If the patient is recumbent, have him stare at the head of the bed.
3. Hold the dropper of mydriatic solution about 1 in. above the conjunctival sac so that it does not touch the globe, the skin, or even (especially) the eyelashes.
4. Pull down on the subpalpebral skin, and drop one drop into the conjunctival sac, not onto the globe. (Once the skin under your finger has been rolled down over the general area of the maxillary zygomatic bony suture, firm pressure will hold the eye open in such a way as to maintain painless exposure of the conjunctival sac against the patient's best efforts. Try it on yourself.)
5. If the patient is uncooperative and has long upper lashes, one may, rarely, have to resort to dropping the fluid on the globe, which may be further exposed by pulling the upper lid superiorly away from the globe. Simply press on the skin above the supraorbital bone and roll the skin superiorly until the eyeball is exposed. Then, press your finger more firmly so that the eye cannot be closed.

   It is not actually necessary for the patient to open his eyes. Simply have the patient lie on his back with his head straight up. Put the drops on the medial puncta, and say "all done." The

drops go in as the patient opens his eyes. Dr Gervais tells children to squeeze their eyelids shut with as much force as possible after the drops get into the eye. As the child is preoccupied with squeezing, the pain of the drops is nullified (the Gervais distraction trick).

6. *Make a note in the record*, especially if you dilate unilaterally. This may save the patient an investigation for neurologic causes of a "blown pupil" when someone else makes rounds at night.
7. If sufficient dilation has not occurred after 10 minutes, instill a second drop.

Methods for Improving Patient Cooperation

During the ophthalmoscopic examination, some patients will close their eyes or abruptly turn their heads away just when you think you have found something of interest. They may say, "The light is too bright." How should you respond in a situation like that? (Write your answer down.)

Obviously, you should not say, "It's not bright," as it is not shining into *your* eye. Nor should you lecture the patient about the difficulty he is causing you. Also, you should not give up because that is unfair to both present and future patients.

You can smile at the patient and say, "I know it's bright. I'll turn it down a little." Turn it to a smaller aperture or try the red-free light. You may wish to add, "But it may still be bright for you, so try to stare at the spot for as long as you can. You are doing a good job."

Neophytes tend to blame problems on themselves, often correctly. Sometimes, they wantonly sweep the light back and forth over the macula before they even have a chance to orient themselves topographically, and the patient is naturally troubled by the repeated macular stimulation. To avoid hitting the macula early, while you are "going in," approach the patient's pupil from the temporal side, rather than directly from the front.

Synopsis of Routine Ophthalmoscopic Examination

This section gives an overview of the order of the ophthalmoscopic examination and the general observations to be made. The remainder of the chapter is concerned with the ophthalmoscopic findings and their significance, as well as specific techniques as they relate to specific findings.

1. *Checking for anterior (corneal and lenticular) opacities*. This part of the examination is done first because it informs us about those central opacities that interfere with subsequent examinations of the fundus oculi. When the retinal structures are in focus, the obstructing opacity cannot be in focus and therefore is not seen. The examiner who is not aware of this will become confused and frustrated by the seemingly inexplicable difficulty experienced in visualizing a relatively large area of the fundus.

   A method: After the red reflex is obtained, with the examining eye and ophthalmoscope held at 2 or 3 ft from the patient's eye, focus on the iris to ascertain that you are in the approximate focal plane of the cornea and lens. Returning your attention to the red reflex, move your head slightly, looking for sharp black opacities to appear in front of the red reflex. You may also focus up and down a few lens settings. Better mannequins have plastic devices that mimic anterior opacities. These can be inserted, and you can practice looking for them.
2. One can next examine the vitreous for opacities and abnormal structures, as an ophthalmologist does. However, this is rarely useful in an asymptomatic patient and almost never produces useful information about the medical condition of the nonophthalmologic patient, except in the case of vitreous hemorrhages, which are almost impossible to miss even if one is not looking for them. Therefore, most diagnosticians proceed from the anterior structures directly to the fundus.
3. *Focusing on the fundus*. Once you have located the optic disc, there are several features for which you must consciously look. Note the color, the size of the optic cup, the presence or absence of papilledema, and the presence or absence of retinal vein pulsations. While following the blood vessels in the sequence previously given (superior temporal, superior nasal, inferior nasal, and inferior temporal), observe the arteriovenous crossings, the retinal background, and the size and appearance of the vessels themselves. Then, swing from the disc temporally about 2 disc diameters to find the macula, which is examined last because it is the most uncomfortable for the patient. The macula is the best place to look for microaneurysms and hard exudates. Do not forget to examine the macula itself. It is somewhat darker than the surrounding retina. At its center is the fovea centralis, which may appear as a small circle with a reddish center, a spot of light, a shifting crescent, a shining line, or a moire pattern. Small vessels appear to converge toward the macula but not actually to enter it.

If the patient does not have cataracts and one still cannot clearly see the fundus, have the patient put on his glasses and repeat the examination; the problem may be a severe astigmatism.

Finally, repeat this sequence for the other eye.

A Philosophic Note. For some reason, the most dramatic findings in the fundus, such as choroidal sclerosis and large black areas due to burned-out chorioretinitis, are never really urgent or acute, whereas the most ominous findings, for example, splinter hemorrhages appearing around the disc, loss of spontaneous retinal venous pulsations, posterior pole drusen in beginning senile macular degeneration, and microaneurysms and exudates in preproliferative diabetic retinopathy, tend to be quite subtle in appearance (Appendix 10.3).

Ophthalmoscopic Findings

Findings in the Anterior Part of the Eyeball

Opacities of the Cornea

Interstitial Keratitis

While looking for the lens, one can sometimes see a haze in the cornea, obscuring the view of the iris. This sign of interstitial keratitis can often be detected by a clinician (although that diagnosis usually requires the special techniques of an ophthalmologist). Sometimes new vessel formation occurs in the healing process, resulting in salmon-colored patches.

Posterior Keratoprecipitates

These round gray spots on the posterior cornea are also called *mutton fat bodies*. Contrary to popular wisdom, posterior keratoprecipitates, although seen in some cases of ocular sarcoidosis,

are not pathognomonic. They may also be seen in the retinopathies of candidiasis (Chumbley, 1981), toxoplasmosis (Havener, 1984; Schlaegel, 1978), Cytomegaloviruscytomegalovirus (CMV) (Chumbley, 1981), tuberculosis, brucellosis (Scheie and Albert, 1977), *Entamoeba histolytica* brain abscess (Walsh and Hoyt, 1969), and boutonneuse fever (*Rickettsia conorii*) (Lebas and Bernaerts-Lebas, 1962). In fact, if searched for, they would probably be found in many other retinopathies and uveitides.

Opacities in the Lens

Cataracts are the most common finding on ophthalmoscopic examination of the anterior eyeball. They may actually be more of a problem for the physician than for the patient. If the cataract is impairing the patient's vision, he should be referred to an ophthalmologist.

Anterior capsular cataracts [indicated by (A) in Fig. 10-15] and corneal opacities can be distinguished from posterior capsular opacities [indicated by (B) in Fig. 10-15]. Look through the ophthalmoscope and through a theoretical point in the center of the lens. Then, instruct the patient to look upward as you continue to maintain a line of sight through the center of the lens (not the globe). This will require you to tilt your line of sight somewhat upward (not shown). Anterior opacities will tend to move up and posterior opacities down (Fig. 10-15).

These days, cataract surgery is rarely associated with serious complications. For this reason, ophthalmologists generally remove cataracts at an early stage. Generalists, with their limited instruments, cannot diagnose these early cataracts (R. Gervais, *personal communication*, 1998).

Ectopic Lens

A simple check for ectopic lens is to examine the red reflex with a penlight. In ectopic lens, there will be an incomplete appearance in the form of an ellipsoid below where one would have expected the full circle of light, somewhat as if a light shade of a concave inferior surface had been pulled down halfway across the pupil (Chan et al., 1987).

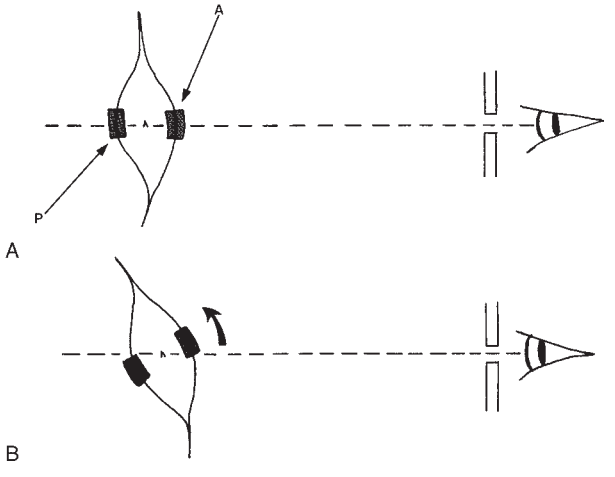


Figure 10-15 Distinguishing anterior (**A**) and posterior (**B**) lenticular opacities. See text.

Ectopic lens occurs in patients with Marfan syndrome *inter alia* (see Chapter 24). The lens may also be dislocated in this condition.

Anterior Chamber Depth

Another method of estimating anterior chamber depth uses the slit aperture on the ophthalmoscope. Shine the light so that you can see the slit reflected from both the cornea and the lens, and observe the distance between the two reflections. To be able to judge that a chamber is abnormally narrow, you will have to have examined a number of normal eyes. Myopic patients tend to have deep anterior chambers.

The Vitreous

The major vitreous finding is vitreous hemorrhage. Another, unexpected finding that may interfere with the examiner's view is asteroides hyalosis ("planetlike structures that are glassy"), which are white or yellowish white spheres made of calcium-containing compounds. These are primarily seen in men of middle age. Oddly enough, they do not impair the patient's vision as much as they impair the physician's inspection, so a complaint of visual impairment should prompt a search for another entity.

Asteroides hyalosis may be mimicked by other diseases that produce a "snowstorm in the vitreous" and that are of significance. These include the ophthalmologic diseases pars planitis (a peripheral uveitis) and retinoblastoma, "medical" diseases such as Behçet syndrome and sarcoid, or any severe form of uveitis (Roy, 1984).

Toxoplasmosis, primarily in AIDS patients, may cause a dense vitritis along with multifocal retinitis, giving a "headlight-in-the-fog appearance" to the lesions (Gariano et al., 1993).

The Disc

Spontaneous Retinal Venous Pulsations

A Method

Look at the largest retinal veins as they course up from the cup of the disc. A momentary tapering or flickering may be seen in the portion of the vein that is almost parallel to the axis of inspection. Retinal venous pulsations are probably never seen in the peripheral venous tree beyond the disc. Digital compression of the eyeball may elicit retinal venous pulsations in some normal persons who did not initially have them. This may be done for teaching and learning purposes, but it should never be part of a patient examination, for the reasons explained below.

Physiology

As shown schematically in Fig. 10-16A, there is normally a pressure differential between the intraocular pressure and the retinal venous pressure, the latter obviously being higher (or the veins would empty and not be seen). During systole, the pulse pressure is briefly transmitted to the intraocular pressure through the expansion of the retinal artery, and this may permit the intraocular pressure to briefly exceed retinal venous pressure. At that moment, the retinal veins begin to *collapse*. As the retinal artery pressure peaks and then drops, the intraocular pressure also drops to normal, allowing *reexpansion* of the retinal vein to its customary diameter. This is seen as retinal vein "pulsation."

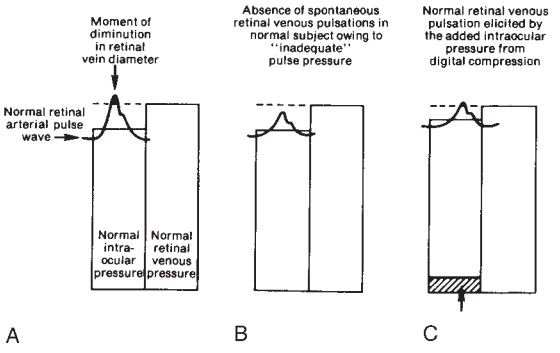

Moment of diminution in retinal vein diameter
Absence of spontaneous retinal venous pulsations in normal subject owing to "inadequate" pulse pressure
Normal retinal venous pulsation elicited by the added intraocular pressure from digital compression
Normal retinal arterial pulse wave
Normal intra-ocular pressure
Normal retinal venous pressure
A
B
C

FIGURE 10-16 **A:** Spontaneous retinal venous pulsations occur in this normal eye in the brief moment that the intraocular pressure plus the transmitted arterial pressure exceed the normal retinal venous pressure. **B:** Spontaneous retinal venous pulsations do not occur in this normal eye because the normal retinal venous pressure is always greater than the sum of the normal intraocular pressure plus the transmitted arterial pressure. **C:** "Nonspontaneous" retinal venous pulsations can be brought out, for pedagogic purposes only, in the normal eye by finger pressure on the eyeball. This maneuver artificially increases the intraocular pressure to a point at which the addition of the transmitted arterial pressure is now sufficient to briefly exceed the normal retinal venous pressure. (From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30:1–64, with permission.)

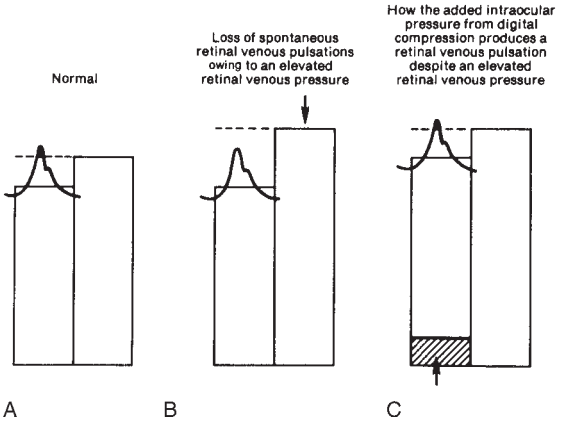

Normal
Loss of spontaneous retinal venous pulsations owing to an elevated retinal venous pressure
How the added intraocular pressure from digital compression produces a retinal venous pulsation despite an elevated retinal venous pressure
A
B
C

FIGURE 10-17 **A:** The same normal eye as shown in Fig. 10-16. **B:** Loss of spontaneous retinal venous pulsations owing to the pathologic increase in the retinal venous pressure. **C:** "Nonspontaneous" retinal venous pulsations inappropriately elicited by means of finger pressure on the eyeball. This should not be done in clinical practice. (From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30:1–64, with permission.)

If the retinal artery is sclerosed and does not transmit pressure well by expansion, retinal venous pulsations may be absent (even with normal retinal venous pressures). This may explain why the incidence of spontaneous retinal venous pulsations decreases with age (Lo Zito, 1977).

An increase in retinal venous pressure will cause the loss of spontaneous retinal venous pulsations, all other things being equal (Fig. 10-17). In cases of increased intracranial pressure, the retinal venous pressure is elevated because the retinal veins traverse the subarachnoid space surrounding the optic nerve. "Nonspontaneous" retinal venous pulsations (Fig. 10-17C), elicited by pressing on the patient's eyeball, could give a false sense of security prior to performing a lumbar puncture. Therefore, this maneuver is contraindicated.

Experimental Evidence

The relationships diagrammed in Figs. 10-16 and 10-17 have been experimentally studied in human subjects. In all 50 patients with spontaneous retinal venous pulsations, the intracranial pressure was less than 195-mm water (Kahn and Cherry, 1950). In all 18 patients with intracranial pressures greater than 195 mm water, spontaneous retinal venous pulsations were absent. In another experiment, ten subjects with spontaneous retinal venous pulsations underwent lumbar puncture. The highest opening pressure was 170 mm water. The cerebrospinal fluid pressure was acutely raised with a digital Queckenstedt maneuver, and the cerebrospinal fluid pressures at which the spontaneous retinal venous pulsations disappeared, and then returned, were observed. The respective means were 204 and 202 mm water, and the highest individual value was 236 mm (Walsh et al., 1968). A study of 400 consecutive neurology consultations in which 65 lumbar punctures were performed revealed no spontaneous retinal venous pulsations in any of the 19 patients with opening pressures greater than 200 mm water. In the 22 patients who had spontaneous retinal venous pulsations, the highest cerebrospinal fluid opening pressure was exactly 200 mm water (Lo Zito, 1977). In still another study, 180 mm water was the highest opening cerebrospinal fluid pressure in 29 patients with spontaneous retinal venous pulsations, and in 9 patients with increased cerebrospinal fluid pressures, the spontaneous retinal venous pulsations disappeared at 190 mm water (Levin, 1978).

The evidence cited above would suggest that 180 to 205 mm water is the general level of the cerebrospinal fluid pressure above which one would not expect to see spontaneous retinal venous pulsations. A single letter to the editor (Van Uitert and Eisenstadt, 1978) reported four patients with opening cerebrospinal fluid pressures of 210 to 280 mm water despite the presence of spontaneous retinal venous pulsations. Unfortunately, the letter does not state how many patients were seen in order to collect these four. These lumbar punctures were uncomplicated, as were two others of the same nature (unreported) of which I have heard.

Significance

In summary, the presence of spontaneous (without digital compression) retinal venous pulsations suggests that the cerebrospinal fluid pressure is unlikely to be elevated. The absence of spontaneous retinal venous pulsations is of no diagnostic utility, as about 20% of normal persons lack them (Whiting and Johnson, 1992).

For the Attending. Because spontaneous retinal venous pulsations are synchronous with the heartbeat and dependent on the stroke volume, they may be lost or irregular in conditions in which the stroke volume is not constant, for example, atrial fibrillation or atrioventricular dissociation.

Although cardiac monitors have removed much of the suspense from the bedside examination of patients, they also give you the opportunity to confound the unsuspecting ignorant by describing to them the events on the monitor as you look into the patient's eye, with the monitor outside your range of vision. This maneuver is recommended to you as a way to obtain wager money to help pay for this text.

Spontaneous retinal venous pulsations are also helpful in distinguishing *diabetic papillopathy*, in which they are present (Barr et al., 1980; Pavan et al., 1980), from papilledema due to increased intracranial pressure, in which they are absent. This is an important

issue because many diabetic patients also have hypertension, and the diabetic hemorrhages and exudates, in the presence of swelling of the disc (*vide infra*), could suggest malignant hypertension unless spontaneous venous pulsations are observed.

However, although the presence of spontaneous venous pulsations tells you that the cerebrospinal fluid pressure is currently low enough to permit a lumbar puncture, theoretically it does not guarantee the absence of brain edema. The sine wave of intracranial pressure might just happen to be at a normal trough value at the moment of your examination.

Can arterial hypertension produce false-normal spontaneous retinal venous pulsations in the presence of elevated intracranial pressure, according to the mechanism shown in Figs. 10-16 and 10-17? Although theoretically possible, this has not been reported. Even the more likely occurrence, false-normal spontaneous venous pulsations (in the presence of elevated intracranial pressure) due to a wide pulse pressure, has not been observed. In cases of very wide pulse pressures (such as those seen in aortic insufficiency and severe hyperthyroidism), what one sees is retinal arterial pulsations (Roy, 1984). When this happens in aortic insufficiency (see Chapter 17), it is called the *Becker sign*.

Papilledema

When papilledema is experimentally produced in animals by creating an increased intracranial pressure, the first observable static changes are loss of the disc margin and swelling of the nerve head (Walsh and Hoyt, 1969), as shown in Fig. 10-18.

Splinter hemorrhages around the disc are also a sign of papilledema. Although they do not develop as early as the other signs, they have the advantage of persisting at the nadir of the intracranial pressure, unlike the loss of spontaneous retinal venous pulsations (discussed above). As hemorrhages occur, uneven dilation of the veins and apparent constrictions of the arterioles may be seen (Fig. 10-19).

Probably no single sign should ever be relied on for making the diagnosis of papilledema. Etiologies of papilledema are listed in Table 10.10.

You may have noticed that the light reflex of the retina's nerve fiber layer, which gives the retina its appearance of having texture, is more easily visualized with red-free than with white light. In papilledema, the nerve fiber layer around the disc loses its usual sharpness, and the examiner, using red-free light, gets the impression that his scope is out of focus because he cannot perfectly sharpen the image of the individual nerve bundle's central light reflexes.

Patients with papilledema often have other signs or symptoms of increased intracranial pressure, such as headache, nausea, vomiting, diplopia, ataxia, or altered consciousness. They may also report transient obscurations of vision, described as visual blackouts lasting seconds to minutes, usually with postural changes or a Valsalva maneuver (Whiting and Johnson, 1992).

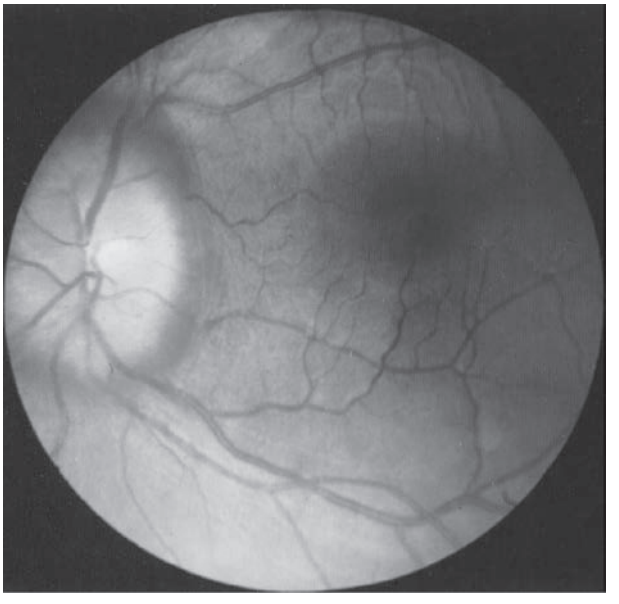
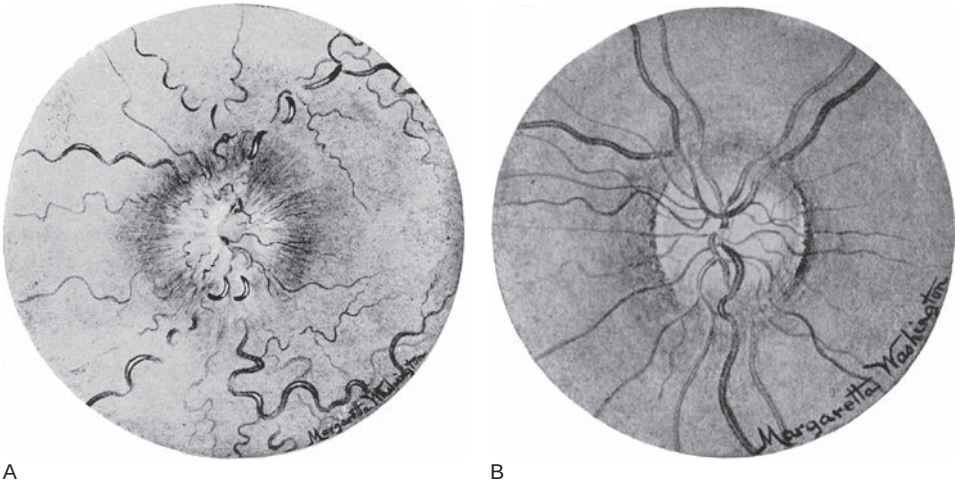


FIGURE 10-18 Blurring and loss of a distinct disc margin are two of the very first signs of papilledema. Normally, there can be slightly less distinction to the temporal margin of a disc without papilledema compared with its nasal margin, but no normal disc would have this much blurring, especially at the superior and inferior margins. What else do you see? No, the dark spot is simply the way the macula photographs. How about the vessels? Although this is a two-dimensional representation, can you see how the vessels are coming off a protruding disc, rather than up from a deep disc? This is the only photograph of papilledema in the book. Compare the disc margins in this picture with the disc margins in Figs. 10-21, 10-30, and 10-34. After a few trials, you should be able to see the difference clearly. Now, try the same thing with the vessels exiting the disc.



A B

FIGURE 10-19 Drawings of an optic fundus before **(A)** and after **(B)** relief of increased intracranial pressure due to a brain tumor, showing papilledema. The drawings are said to show 6 diopters of swelling and its regression. (From De Schweinitz GE. *Disease of the Eye: A Handbook of Ophthalmic Practice for Students and Practitioners*. Philadelphia, PA: W. B. Saunders; 1915, with permission.)

TABLE **10.10** *Causes of papilledema*

- With visual impairment (Duke-Elder and Scott, 1971)
  - Papillitis of any cause
- Without visual impairment
  - Idiopathic intracranial hypertension
  - Intracranial tumor of any type
  - Intracranial infection of any type
  - Vascular disease
    - Subarachnoid hemorrhage
    - Subdural hematoma
    - Hypertensive encephalopathy
  - Retinal vascular disease
    - Central retinal vein thrombosis
    - Cavernous sinus thrombosis
    - Retinal vasculitis of any type
  - Metabolic
    - Hypervitaminosis A
    - Ethylene glycol poisoning
    - Lead poisoning
    - Arsenic poisoning
    - Carbon dioxide retention
    - Hyperthyroidism
    - Mucopolysaccharide metabolism disorder
  - Guillain–Barré syndrome
  - Decreased intraocular pressure of any cause
  - Congenital malformations
  - Hematologic disease
    - Severe anemia
    - Polycythemia
    - Leukemia
    - Thrombotic thrombocytopenic purpura
  - Shunt obstruction

From Duke-Elder S, Scott GI. Neuro-ophthalmology: XII. In: Duke-Elder S. ed. *System of Ophthalmology*. St Louis: CV Mosby; 1971; Havener WH. *Synopsis of Ophthalmology: The Ophthalmoscopy Book*. 6th Ed. St Louis: CV Mosby; 1984; Newell F. *Ophthalmology: Principles and Concepts*. 8th Ed. St Louis: CV Mosby; 1982:559; Roy FH. *Ocular Differential Diagnosis*. 3rd Ed. Philadelphia, PA: Lea & Febiger; 1984; and Whiting AS, Johnson LN. Papilledema: Clinical clues and differential diagnosis. *Am Fam Physician*. 1992;45:1125–1134, with permission.

Pseudopapilledema

Many conditions can imitate papilledema, for example, hypermetropia, in which the disc border may appear indistinct, especially temporally. There is no true protrusion of the disc, as can be shown by using the light stripe or by simply focusing up and down on the nerve head. The discs of some patients with astigmatism may have a similar appearance. The following listing is doubtless incomplete, especially for conditions that would be seen on the ophthalmology service (Roy, 1984).

Myelinated (also called *medullated*) nerve fibers, a congenital defect, also mimics papilledema. The myelinated nerve fibers arising from the disc are opaque, the color of white eggshell, rather than transparent. They are usually unilateral, whereas papilledema is usually bilateral. ("Usually" here means 80% of the time.) The disc margins in myelinated nerve fibers will *always* have a fluffy or feathery edge, as if someone had taken a paintbrush and swept white paint out from the disc. The feather is composed of a bundle of myelinated nerve fibers, each fiber making a barb. (The only other ocular finding that has a feathery edge is the red flame hemorrhage.) Although myelinated nerve fibers may rarely be seen with neurofibromatosis or with cranial dysostosis, they otherwise have no association with any medical disease.

A variety of tumors can obscure the disc, fooling the unwary or inexperienced. These include tumors of the eye tissue itself (gliomas, meningiomas, and neurofibromas or the hamartomas of tuberous sclerosis) or metastatic tumors.

Pseudopapilledema may also be caused by Bergmeister papilla, a glial sheath that surrounds the first one third of the hyaloid artery. It is a normal embryonic sheath that occasionally persists in the adult as a small tuft of tissue replacing the physiologic optic cup of the disc.

Colloid bodies of the disc (also called *hyaloid bodies*) may cause cuneate visual field defects and obscure the disc borders. The appearance is like that of small (50 to 100 μm) and later large blobs (500 to 600 μm in diameter) of pineapple gelatin on the disc.

Although they may simply be inherited as an autosomal dominant with no systemic significance, colloid bodies are also seen variously in association with retinitis pigmentosa, Friedrich ataxia, Wilson disease, glaucoma, syphilis, pseudoxanthoma elasticum, and hypermetropia with disc elevation. Tuberous sclerosis is often listed in the differential diagnosis, but on histologic examination, the apparent hyaloid bodies turn out to be little hamartomas.

Colloid Body: A Case Report

A 48-year-old professor of medicine presented himself to the eye clinic with a chief complaint of, "I've got a quadrant field cut on the right," of less than 18 months' duration. The professor had just been teaching visual fields by confrontation to his sophomore physical diagnosis students, as had been his habit for several decades. After his standard lecture, which included the facts that temporal brain tumors caused an upper quadrantanopia, while parietal brain tumors caused a lower quadrantanopia, he proceeded to the practicum. To his amazement, he could no longer see his own fingers when they were in the right lower quadrant.

The onset of this change could be dated within the prior 18 months, when he had moved to an Eastern medical school where physical examinations were no longer performed with any care or skill, and so he had not been presented a single case of a visual field cut to be checked by confrontation.

Physical examination revealed a sweating, apprehensive, middle-aged white man who had a cuneate monocular right lower quadrant field cut with central sparing. On funduscopic examination, the right disc had a colloid body. Extensive studies, including a computerized axial tomography scan of the brain, revealed nothing. Repeated Goldmann perimetry revealed stability of the lesion over a 6-month period, an important issue because owing to his peculiar occupation the professor was able to date the appearance of the

quadrantanopia, and so was suspected of being hysterical by one of his consultants, who had not grasped the significance of the colloid body.

For the Attending. Colloid bodies (also misnamed "disc drusen") are acellular concretions of periodic acid Schiff (PAS)-negative material, which has a whorled appearance that can be observed on electron microscopy. On chemical analysis, it yields a positive test for sphingomyelin. True drusen, much smaller structures not found on the disc, are PAS-positive accretions on Bruch membrane and show no whorling or sphingomyelin. Other differences will no doubt be discovered. Without knowing that these two completely dissimilar structures have been called by the same names, it becomes impossible to understand the ophthalmologist's literature or consultation notes.

Retinal Neovascularization

Neovascularization is the proliferation of very small new vessels into an area where they formerly did not exist and are not normally seen. This usually occurs around the disc. When it involves the macula, it may cause blindness. Normally, the retinal vasculature does not send new sprouts into territory that it does not usually supply. Furthermore, the normal vitreous and retina contain a substance that inhibits new growth of vessels. Thus, neovascularization implies both an abnormality of the microvasculature and a disease of the retina. The most common causes are diabetes mellitus, the various hemoglobinopathies, and sarcoid.

Glaucoma

The word *glaucoma* is thought to come from the Greek word meaning "shining" or "sparkling." It is believed that this was intended to distinguish those who were blind from cataracts (whose eyes were no longer shining) from those who were blind from glaucoma. The importance of this etymology is to remind you of the insidiousness of glaucoma: to an untrained observer, the eyes seem to be normal, while the blindness progresses. As the painless increase in intraocular pressure jeopardizes the blood flow to the eye, the peripheral fields constrict. Because central vision is preserved to the end, the patient may not notice the problem until all other vision is lost (Johnson and Brubaker, 1986).

Despite the effective surgical and pharmacologic remedies available these days, glaucoma is a leading cause of blindness in the United States. If someone does not make the diagnosis, the patient might as well be living in ancient Greece as far as the preservation of his sight is concerned.

Glaucomatous changes in the disc are listed below. After studying this portion of the text, you should be able to screen all your patients for glaucoma and selectively refer suspected glaucoma victims for consultation. Your batting average will improve with practice and good consultants. The funduscopic findings should heighten your index of suspicion for glaucoma, but you should proceed to a pressure measurement at the drop of a hat. Good ophthalmologists measure intraocular pressure routinely.

1. *Deepening of the optic cup*. As the glaucomatous globe sustains its chronic hypertension, the optic cup begins to excavate, and the blood vessels exiting the disc come to be concealed beneath the lip of the disc (Fig. 10-20). This sign, like many of the others, has a good specificity but a lesser sensitivity. The only potential false positive is the cilioretinal vessel, which is easy to identify once one knows of it (see legend to Fig. 10-20C).
2. *Cup/disc ratio*. With increasing pressure over time, the cup/disc ratio may increase (Fig. 10-21), and this can be clinically estimated with sufficient intraobserver reliability to be useful. The disc is the entire creamy yellow structure. The cup is the part of the disc from which the vessels emerge. Its focal plane is farther away from the examiner. Determining exactly where the cup

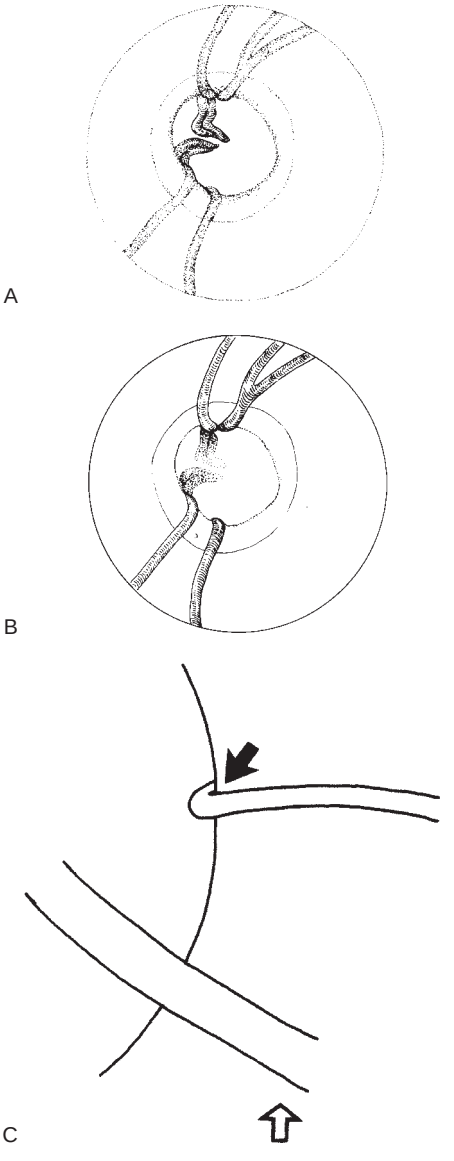


FIGURE 10-20 **A, B:** Disc whose cup is quite deep. In (**A**), one can focus on the vessel emerging from the deep cup, but one cannot as clearly see the vessels as they exit the disc. In (**B**), one sees the vessel going under the lip of the disc and the distal vessel emerging, but one cannot see the proximal vessel clearly. **C:** Normal vessel exiting the disc at the bottom (*hollow arrow*). One can also see a "false-positive" cilioretinal artery exiting the disc in a manner faintly suggestive of a true glaucomatous vessel (*solid arrow*). This cilioretinal artery is always smaller than the normal artery. Furthermore, although it exits the disc by coming over the edge like a glaucomatous vessel, the more proximal portion of the cilioretinal artery cannot be identified, as would be the case with a true glaucomatous vessel (compare with [**B**], above).

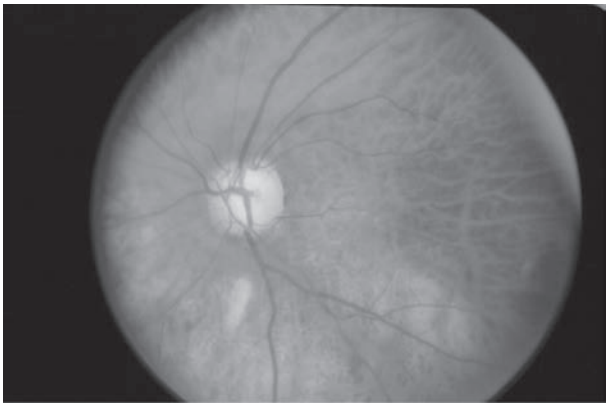


FIGURE 10-21 A glaucomatous disk, showing a large cup/disk ratio, with thinning of the temporal retinal rim in keeping with a visual field defect known as a nasal step. Note the steep dipping (at the superior edge of the cup) and kinking (at the inferior edge) of blood vessels as they course over the neuroretinal rim into the excavated optic nerve cup. (Photograph courtesy of Dr Sean McCafferty of Tucson, Arizona, with permission.)

begins is somewhat arbitrary; your job is to be arbitrary in the same way each time.

The average cup occupies only 30% of the disc surface. However, some normal persons can have very large cups. Accordingly, this sign, like the others, is not pathognomonic for glaucoma. A few facts (Armaly, 1967) will provide perspective. Of normal subjects, 99% have optic cups that occupy less than 70% of the disc. If your patient has a cup bigger than 70% of the disc, he probably has glaucoma. An intereye discrepancy between the two cups of greater than 20% of the respective disc area also suggests glaucoma. Many patients with glaucoma do not have increased cup/disc ratios, so the sign is not highly sensitive, although it is the one that best predicts future damage.

3. *Nasalization of the vessels*. A peculiar phenomenon of glaucoma is that most of the vessels seem to be coming from the nasal side of the disc, whereas usually they radiate from both the nasal and temporal sides.
4. *Pallor*. Pallor of the disc is a relatively late sign.
5. *Vertical ovality of the optic cup*. Ordinarily, the optic cup, if oval, has a horizontal long axis. In glaucoma, the oval optic cup tends to have its long axis vertical.
6. Other "soft" signs include notching of the disc (either inferior temporal or superior temporal), flame or splinter hemorrhages on the disc (Table 10.25), and the appearance of laminar dots (because of the exposure of the lamina cribrosa, which is stippled).

The list is incomplete, and none of the signs are perfect (Heilmann and Richardson, 1978). However, it is arguable that any two items in the above list should be considered reasonable evidence of glaucoma, and the higher the finding on the list, the more certain it is that the tentative diagnosis is correct.

The diagnostic accuracy of inspection of the disc alone was evaluated for 372 normal eyes and 132 glaucomatous eyes in a blinded study that used stereophotographic slides, measurement of intraocular pressure, and Goldmann perimetry to detect peripheral visual field loss. The sensitivity of the test (inspection of the disc) was 89% and the specificity was 93% (Hitchings and Spaeth, 1977). Another study of 22 patients found direct ophthalmoscopy to have a sensitivity of only 48% and a specificity of 73% (Wood and Bosanquet, 1987).

Special Equipment

1. Stereoscopic viewing is probably the earliest and best method for detecting optic nerve damage from glaucoma before 50% loss of nerve tissue has occurred. However, the special equipment is usually not available to the nonspecialist.
2. Visual field defects on the perimetry might be placed just after changes in the cup/disc ratio on the list above. Visual field testing by confrontation is simply not sensitive enough to pick up the early field defects, which occur in the midperiphery and later become arcs surrounded by good visual fields on all sides. Formerly, one would have recommended a tangent screen examination, done with a black velvet backdrop into which pins with white or red heads could be inserted. These screens have disappeared, to be replaced by Goldmann perimetry done by specialized technicians, which in turn has been supplanted by computerized perimetry. The middle has been vacated, so there is no longer a reasonably good technique available to the frontline undifferentiated physician for picking up small nasal defects.

Optic Atrophy

The disc is usually creamy yellow, like hollandaise sauce. In optic nerve atrophy, it becomes bone white, like béchamel sauce. Causes are listed in Table 10.11.

Hyperemia of the Disc

The normal color of the disc varies considerably. A hyperemic disc is described as being somewhat redder than usual, and this can occur in a variety of conditions (Table 10.12).

In the bourbon country of Kentucky, the special bourbon barrels are cleaned with methanol so that they can be reused. The material that comes out of the cleaned barrels (smoky, bourbon-colored methanol) is called "heads" and is a cheap but potentially lethal form of beverage alcohol. Oddly, some patients who have survived a bout of methanol poisoning from the ingestion of "heads" have been known to reappear in the hospital after a second ingestion.

Some of the patients do not die from the methanol ingestion but instead have retinal poisoning. At first, the disc is hyperemic, but later, with the death of the retinal cells, there is edema and finally pallor of the disc. The patient is left blind. (It has been suggested that this is the origin of the term "blind staggers.")

A more likely source of methanol these days is overingestion of aspartame-sweetened beverages (see Chapter 3).

Retinal Streaks, Stripes, and Defects

Angioid Streaks

Angioid streaks are fault lines in Bruch membrane, which result from breaks in elastic fibers, and are usually lighter than the retinal background. Because they radiate out from the disc and are of relatively constant diameter, they may look like vessels (hence the term *angioid*). They may be much shorter than vessels. They will always appear to be under the real retinal vessels (Fig. 10-22). This

TABLE **10.11** *Causes of optic atrophy*

Consequent to optic neuritis, including
- Multiple sclerosis

Other diffuse sclerotic diseases (Schilder and the leukodystrophies)
Hereditary/congenital
Secondary to papilledema
Vascular
- Temporal arteritis

Postischemia (as in thrombosis of either the central artery or vein of the retina)
- Syphilis

Traumatic
- Surgery
- Blows on the head
- Avulsion of optic nerve

Compressive
- Glaucoma
- Neoplasm
- Craniometaphyseal dysplasia
- Aneurysm

Toxic and metabolic (temporal pallor more prominent)
- Vitamin deficiencies
- Carbon monoxide poisoning
- Tobacco–alcohol amblyopia
- Ethylene glycol intoxication (Ahmed, 1971)
- Postmethanol poisoning

Ophthalmologic
- Optic nerve colloid bodies

From Roy FH. *Ocular Differential Diagnosis*. 3rd Ed. Philadelphia, PA: Lea & Febiger; 1984, with permission.

TABLE **10.12** *Causes of hyperemia of the disc*

Papilledema
Polycythemia
Hypermetropia
Optic neuritis
Neovascularization
Central retinal vein thrombosis
Hemangioma
Ischemic optic neuropathy
von Hippel–Lindau disease
Methanol ingestion

From Duke-Elder S, Scott GI. Neuro-ophthalmology: XII. In: Duke-Elder S. ed. *System of Ophthalmology*. St Louis: CV Mosby; 1971 and Roy FH. *Ocular Differential Diagnosis*. 3rd Ed. Philadelphia, PA: Lea & Febiger; 1984, with permission.

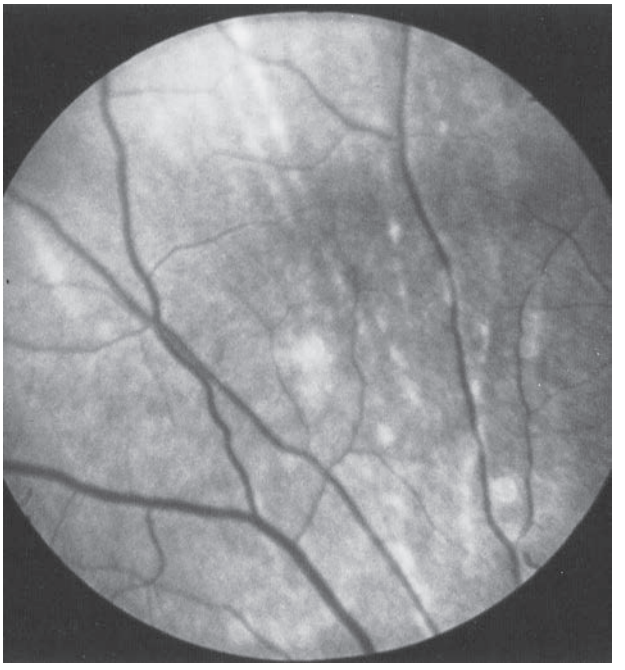


FIGURE 10-22 The light lines running underneath the vessels are angioid streaks.

is a rare finding that indicates a search for the medical conditions given in Table 10.13. The ophthalmologic significance is that breaks in Bruch membrane lead to neovascularization from the choroid and consequent hemorrhages.

Pseudoangioid Streaks

Pseudoangioid streaks do not appear to radiate from the disc. The most common cause of pseudoangioid streaks is a misinterpretation of the areas commonly seen in the fundi of lightly pigmented individuals, which permit the examiner to see large choroidal vessels through the retinal pigment epithelium and have no clinical significance. This appearance may also be called a *tigroid fundus*.

Lacquer cracks, seen in high myopia, are small linear defects in the macula. They are breaks in Bruch membrane, which can lead to neovascularization beneath the retinal pigment epithelium.

In "choroidal sclerosis," which has as its outstanding feature the atrophy of the retinal pigment epithelium, the choriocapillaris may become visible and this can resemble angioid streaks.

Retinal Detachments

Occasionally, you will see an unusual streak, which is not due to a change in color or background but is due to a change in contour, as if the retina were folded up, somewhat like a bath mat whose edges have been pushed slightly toward the center. This is a retinal detachment, which requires immediate ophthalmologic consultation to prevent irreversible loss of vision. You want the patient to see a specialist *before* the picture shown in Fig. 10-23 appears. The earliest change is an alteration in refraction in the area of separation. The normal color is eventually lost, the detached portion appearing as a gray or gray-green membrane. The choroid may sometimes be seen through rents in the detached retina.

TABLE **10.13** *Angioid streaks*

Diagnostic entity	% of cases (of this entity) that have streaks	% of all cases of angioid streaks caused by this entity
Pseudoxanthoma elasticum	85–87	59
Paget disease	8–15	14
Sickle hemoglobinopathies	0–27	7
Pituitary tumors	Rare	Very rare
Familial hyperphosphatemia with metastatic calcification	All	So rare it is reportable
Associations of uncertain significance: calcinosis, optic atrophy, systemic lupus erythematosus, ipsilateral facial angiomatosis, posthemorrhagic retinal hemorrhages		
Highly questionable associations: carotid aneurysm, hemolytic anemia, trauma, retinitis albuminuria, lead poisoning, diffuse lipomatosis, dwarfism, epilepsy, senile actinic elastosis		

From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30:1–64, with permission.

Figure 10-23 Drawing of a fundus with retinal detachment. (From De Schweinitz GE. *Disease of the Eye: A Handbook of Ophthalmic Practice for Students and Practitioners.* Philadelphia, PA: W. B. Saunders; 1915, with permission.)

Patients complain of distortion of objects; floating spots before the eyes owing to the frequent presence of vitreous opacities; an appearance like a cloud, owing to the scotoma produced by the separated area; and phosphenes or bright visual images, like those elicited by mechanical pressure on the eyeball, although these cannot be elicited by pressure on the eyeball over the separated area.

Patients who complain of brief flashing lights are likely to have a posterior vitreous detachment, which can cause a retinal tear. They should promptly be referred for indirect ophthalmoscopy, as early laser treatment of a retinal tear can prevent detachment. The progression to retinal detachment occurs over days to weeks.

Direct ocular trauma, breaching the protection of the orbit, causes commotio or edema of the retina. If there is a vitreous detachment, it can cause a vitreous hemorrhage, with or without an associated retinal tear, which can progress to a retinal detachment. Hyphema (blood in the anterior chamber) is another possible consequence of trauma. Patients hit in the eye with small objects, such as a projectile from a BB gun, require careful follow-up by an ophthalmologist.

Coloboma

A congenital defect of the retina and choroid in which the embryonic fissure fails to fuse properly is called a *coloboma*. It appears as a large white area of absent retina and choroid through which the sclera is seen. Some retinal vessels may cross into the area. Typically, a coloboma is inferior in location.

Arteriosclerosis of the Retinal Arteries and Arterioles

Caveat Lector

The statements made in the next section have aroused the ire of many a medical schoolmarm, and the politic reader may wish to skip this entire section. However, the student is warned that the instruction of the "experts" will leave him just as confused as I was at his age, and he might be better-off swallowing the following passages whole.

One of the beauties of physical diagnosis is that the tools are available to all, not just those skilled in fine tuning separatory devices and radioligands. Thus, any reader, as a good scientist, can decide the truth or falsity of these passages. The material is fully referenced elsewhere (Sapira, 1984) so that any reader with scholarly skills and tenacity can make his way back through the labyrinth of scientific discovery and penetrate the curtains of our regularly recurring professional amnesia.

Introductory Summary

"Arteriosclerosis" refers to any one of the forms of hardening of the arteries (Table 10.14). One of these, atherosclerosis, rarely shows up in the fundus, and when it does, it affects only the vessels near the disc as only these are still true arteries (i.e., they have a muscularis layer). Another one, arteriolar sclerosis, refers to the name of both a process and certain ophthalmoscopic findings. This normal aging process is so accelerated by untreated chronic moderate hypertension that its ophthalmoscopic appearance can be clinically useful.

From the 1950s to the 1980s, there was pathetically little research on the pink hyaline of arteriolar sclerosis, whereas every medical school or hospital with more than ten residents had at least one local authority on atherosclerosis. Accordingly, atherosclerosis was the predominant type of arteriosclerosis mentioned in the clinical literature, and those two words became synonymous in the minds of many. As these minds aged and began to write chapters in

TABLE **10.14** *The pathologic subdivisions of arteriosclerosis*[a]

1. Arteriolar sclerosis of hypertension
   a. Arteriolar sclerosis (see text)
   b. Hyperplastic arteriosclerosis (The famous "onion skinning" seen in renal biopsies. It cannot be seen ophthalmoscopically and so is not discussed in the text.)
   c. Fibrinoid necrosis of the arterioles (A sign of acute accelerated hypertension; it cannot be seen ophthalmoscopically, although it undoubtedly covaries with the hemorrhages and exudates of neuroretinitis.)
2. Atherosclerosis (literally, porridge hardening, because the fatty plaques look like porridge.) Although accelerated by hypertension, it may occur independently of hypertension (see text).
3. Mönckeberg's medial calcific sclerosis (It has no relationship to hypertension, and it cannot be diagnosed ophthalmoscopically, so it is not discussed in the text.)

[a]Literally, hardening of the arteries.
From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30:1–64, with permission.

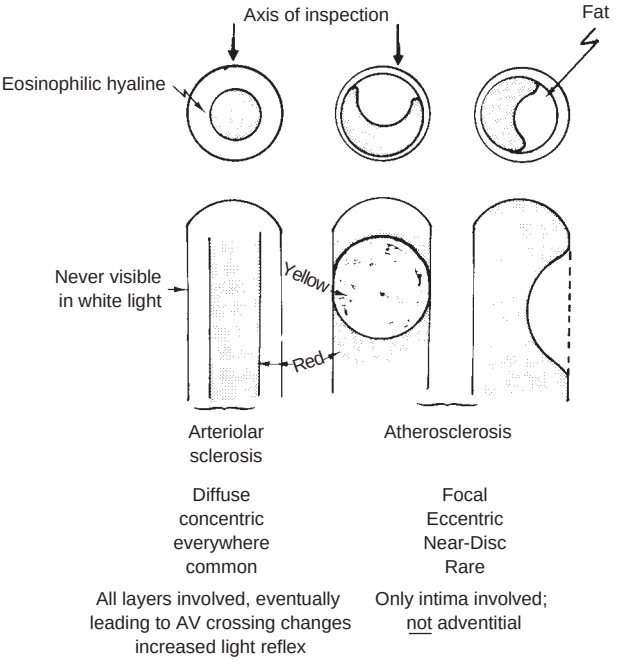


FIGURE 10-24 Arteriolar sclerosis compared with atherosclerosis. (From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30:1–64, with permission.)

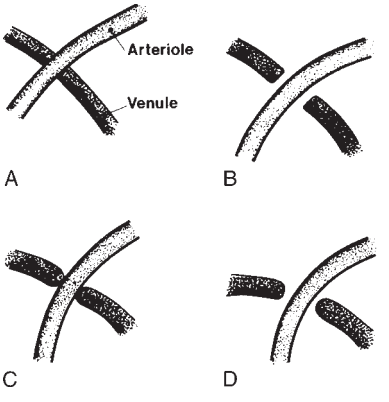


FIGURE 10-25 Arteriovenous crossings. **A, C:** "Arteriovenous nicking" or "arteriovenous changes" by our strict criteria are not shown, even though the ends of the vein are tapered in (**C**). **B, D**: The crossing change is shown that is evidence of chronic moderate hypertension if more than 2 disc diameters out. (From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30:1–64, with permission.)

textbooks, the error became institutionalized. Naive readers, their sophomore pathology concept of arteriolar sclerosis unreinforced, slowly abandoned arteriolar sclerosis as perhaps only the memory of a dream. However, the pictures in the ophthalmologic literature (Scheie, 1953) and in Robbin's textbook of pathology are not hallucinations.

Atherosclerosis is thought to be a fat-mediated disease, whereas arteriolar sclerosis is a "wear-and-tear" disease. Figure 10-24 shows how the two different diseases have two different histologic bases producing two different ophthalmoscopic appearances.

The major retinal findings of arteriolar sclerosis are as follows: (a) arteriovenous crossing changes, (b) changes in the arteriolar light reflex, (c) tortuosity of the arterioles, (d) focal narrowing of the arteriolar blood column, and (e) diffuse arteriolar narrowing.

Arteriovenous Crossing Changes

Thesis

As a rule of thumb, complete arteriovenous crossing changes more than 2 disc diameters away from the disc are due to chronic, moderate hypertension.

Method and Criteria

Each of the four major vascular systems is examined in the sequence given above. Once the examiner is *more than* 2 disc diameters away from the disc, the arteriovenous crossings are specifically examined for *complete* nicking (Fig. 10-25). This requires a perfectly clear space on each side of the arteriole (not owing to arteriolar sheathing).

If one does not require precise criteria for arteriovenous crossing changes, one will do no better in terms of replication than the experts did in the four World Health Organization (WHO) studies, summarized in Table 10.15. Because arteriolar sclerosis is a normal accompaniment of aging, albeit accelerated by hypertension, it is important for us to insist on the presence of the extreme case in order to relate the findings accurately to chronic moderate hypertension per se.

Of course, the strictness of the criteria will decrease the sensitivity of the crossing changes for detecting chronic hypertension. However, it will increase the specificity and positive predictive value of the observations by decreasing the number of false positives. Another way of looking at this is that changing the criteria substitutes one type of error for another, as shown in Fig. 10-26. In this case, the use of stricter criteria accepts a beta (type II) error so as to be free of alpha (type I) errors, as defined in Table 10.16.

TABLE **10.15** *Four WHO studies of clinical ophthalmoscopy and arterial hypertension*[a]

	Study no. and technique			
	1 Ophthalmoscopy	2 Black-and-white photos	3 Color photos	4 Color photos
No. of experts	6	7	37	7
No. of fundi examined	48 (twice)	33 (twice)	50 (twice)	156 (55 twice)
Diffuse arteriolar narrowing	29 (21)	33 (15)	34 (22)	42 (33)
Localized arteriolar narrowing	31 (25)	24 (14)	37 (27)	20 (19)
Increased light reflex	24 (14)	21 (10)	31 (21)	Not done
AV crossing changes	33 (26)	43 (23)	24 (21)	23 (22)

[a]After line 3, data represent percentage of mean interobserver disagreement with percentage of mean intraobserver disagreement in parentheses.
From Kagan A, Aurell E, Dobree J, et al. A note on signs in the fundus oculi and arterial hypertension: conventional assessment and significance. *Bull World Health Organ.* 1966;34:955–960, with permission.

Etiology

The revealed wisdom (on and off since 1905) is that the artery has occluded the vein. In fact, this could not be so or there would be signs of segmental venous occlusion. Histopathologic studies of crossing changes previously examined in vivo have shown repeatedly that the "compression" is more apparent than real.

The disappearance of the vein in the vicinity of a retinal artery or arteriole is, like the disappearance of the magician's assistant in the stage cabinet, merely an optical illusion. Just as the magician uses mirrors to produce the illusion, so an altered refractile property of the retinal tissues at the arteriovenous crossing produces the illusion that the vein has disappeared (Sapira, 1984).

This material of altered refractile property may be of several origins. First, it may be due to scarring of the common arteriovenous adventitia at the arteriovenous crossing (the only place in the body where there is a shared adventitia). This is produced by arteriolar sclerosis (a process that is accelerated by chronic hypertension). Second, it may consist of very dense glial elements; this is the etiology of the normal arteriovenous crossing changes near the disc (Seitz, 1964; Shelburne, 1965). Third, and rarely, tumors in the fundus oculi may produce arteriovenous crossing changes in nearby vessels, by the glial mechanism or by retinal edema. ("Rarely" here means about once in an examiner's decade.) Fourth, and also rarely, retinal edema as in very severe cases of anasarca from undialyzed

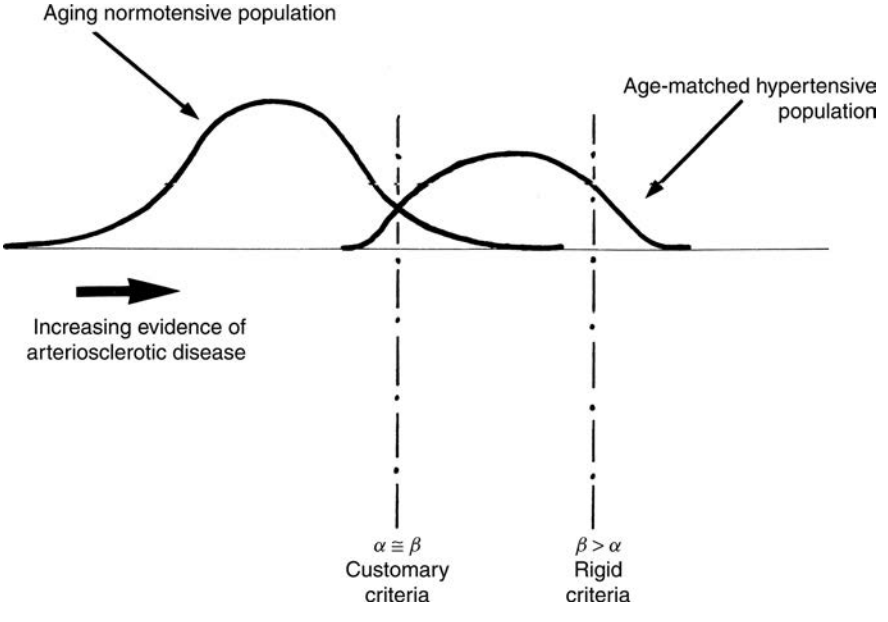


FIGURE **10-26** A comparison of the rigid criteria (complete arteriovenous crossing changes more than 2 disc diameters away from the disc) with the customary criteria (which are not well defined) for arteriovenous crossing changes. The *alpha* error is given by the area under the probability distribution function (shown here as a Gaussian, an idealized situation that frequently does not apply in medicine) for the aging normotensive population that lies to the right of the cutoff point (for either set of criteria). The *beta* error is the area under the curve for hypertensives that lies to the left of a cutoff point.

TABLE **10.16** *Definitions: alpha and beta errors*

Hypothesis or error	Definition
Null hypothesis	The hypothesis that there is no difference between the experimental group and the control group, or, in terms of sampling theory, that both sets of observations could have been randomly drawn from the same sampling universe.
Alpha or type I error	The rejection of the null hypothesis when the null hypothesis is actually true. (This corresponds to the erroneous belief that there is a significant difference between experimental and control groups when there actually is no such difference.) The ***P* value** is the probability of type I error. Clinically, the situation in which the examiner believes the sign signifies abnormality when the patient is actually normal.
Beta or type II error	The acceptance of the null hypothesis when the null hypothesis is actually false; that is, a significant difference between the experimental and the control groups is missed. The **power** of a test is (1 – probability of type II error). Clinically, the situation in which the examiner believes the patient to be normal when in fact the patient is not.

TABLE **10.17** *Causes of sheathing*

- Arteriolar
  - Hypertension
  - Kimmelstiel–Wilson syndrome
  - Leukemia
  - Mycosis fungoides
  - Syphilis
  - Onchocerciasis
  - Polyarteritis nodosa
  - Trauma
  - Sickle hemoglobinopathy
- Venous
  - Hypertension
  - Diabetes mellitus
  - Myelocytic leukemia
  - Syphilis
  - Tuberculosis
  - Candidiasis
  - Coccidioidomycosis
  - Sarcoidosis
  - Multiple sclerosis
  - Normal variant

From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30: 1–64, with permission.

Kimmelstiel–Wilson disease or acute tsutsugamushi disease has caused the alteration in the normal refractile properties of the retina.

Additionally, what is called "arteriolar sheathing" (Table 10.17) may produce pseudoarteriovenous crossing changes, but these are easy to detect because the arteriolar sheathing consists of white stripes at the edge of the red arteriolar stripe; the other types of arteriovenous crossing changes do not have such an easily observed change. Myelinated nerve fibers can have the same effect, but again, the correct diagnosis is obvious on other grounds.

Red-free Light

To learn to use the red-free light to make judgments about adventitial thickening (and medial thickening also), find a hypertensive patient with complete arteriovenous crossing changes more than 2 disc diameters away from the disc. After locating such a crossing change with the usual white light, slip your ringer down to the aperture selector and flick the red-free light into position as you continue to observe the crossing. Concentrate on the area of the arteriole near the crossing, especially just outside the arteriolar blood column. You will notice a refractile or ghostly appearance parallel to the blood column. It may be necessary to flick the white light back on and off a few times to convince yourself that the refractile quality is only observable under the red-free light.

To convince yourself that this appearance is specific for vessel-wall thickening, examine two other types of vessels, which will not show this phenomenon: the arteriovenous crossing changes of normal persons, near the disc; and the distal arterioles of a normotensive person's fundus.

Significance

About 96% of those hypertensive patients who have arteriovenous crossing changes by the strict criteria will also have cardiomegaly (including left ventricular hypertrophy) caused by chronic moderate hypertension (Shelburne, 1949). This finding can be helpful in assessing the duration of uncontrolled hypertension in a patient seen for the first time, when no records are available. It can also be helpful in definitely assigning a hypertensive etiology to a patient who has cardiomegaly (although hypertensive cardiomegaly can occur before the arteriovenous crossing changes). Similarly, the arteriovenous crossing changes can be useful in a patient suffering from both hypertension and renal failure. The azotemia of hypertensive arteriolar sclerosis does not supervene until there has been enough chronic moderate hypertension to produce the arteriovenous crossing changes (Shelburne, 1949). Thus, in a hypertensive patient with renal failure but no arteriovenous crossing changes, one should think either of primary renal disease with secondary

hypertension or an episode (current or remote) of malignant hypertension inducing renal failure; the latter is easily diagnosed on other grounds.

The arteriovenous crossing changes are permanent (Sapira, 1984; Shelburne, 1965) and thus constitute permanent records of what has happened to the patient's vascular system.

Because the hypertension merely accelerates the arteriolar sclerosis that accompanies aging, even the strict criteria should eventually break down in a nonagenarian with a high normal diastolic pressure. For instance, if these changes appear with only 10 years of 40 mm Hg excess pressure (say a diastolic of 120 minus a "normal" of 80 mm Hg), there is no reason why it should not appear with 50 years of 8 mm Hg excess pressure (a diastolic of 88 mm Hg)—both patients have 400 "mm Hg years." Of course, it is not possible to prove a negative proposition (e.g., "complete arteriovenous crossing changes are not found in normals"). Yet a critical review of the literature (Sapira, 1984) has produced little, if any, evidence that the rigid criteria do break down in practice.

Our knowledge of the evolution of arteriovenous crossing changes is largely derived from the observations of Shelburne between 1929 and 1969. For most of his career, there were no efficacious treatments for hypertension, and Shelburne was willing to do that which most clinical scientists avoid today: make careful long-term clinical observations on patients with an (currently) untreatable disease. Today, it would not be ethical to so study the natural history of arteriovenous crossing changes (i.e., to withhold treatment for 10 to 15 years).

A Buccolingual Pedagogic Note. The Miracle of the Right Eye. After discussing arteriovenous crossing changes, I must recount one of those rare medical experiences that truly deserve to be described as miraculous.[4]

I saw a patient who had, some 20 years earlier, undergone enucleation of the right eye following trauma. Initially, he had a glass prosthesis placed, but some short time after this, the right eye apparently grew back in. The evidence for this last statement comprises the many subsequent notations in the chart stating that the eyes were normal. One careful observer found that the pupils had become equal and reactive to light and accommodation, so even the nerves must have grown back into the new eye. Furthermore, the new eye developed the same retina as the old eye; the patient's old arteriovenous crossing changes recurred within 1 year, according to the notes of two observers, although it usually takes from 7 to 10 years of chronic moderate hypertension to produce such changes. This miracle was documented for some 20 years, but shortly before I saw the patient in the fall of 1985, the second eye apparently evaporated, and it became necessary for him to again begin wearing a prosthesis. It was truly providential that the records of these many interesting eye examinations were not lost because by this time the patient had become demented and could not tell us what had happened to him.

For the Attending. Other clinicians in teaching hospitals have also seen examples of this phenomenon. I had previously seen two others but none so well documented.

[4] From the Latin "tongue'n cheek."

Changes in Arteriolar Light Reflex

Changes in the arteriolar light reflex have been described as "copper" or "silver wiring." Figure 10-27 offers a schematic explanation of how such changes come about. For the changes to be attributed to arteriolar sclerosis, they must be diffuse because many segmental arterioles that have once experienced an occlusion will also show silver wiring.

Although these descriptions, which refer to an external standard, are acceptable, the light reflex should not simply be called "increased" without criteria. Using such a vague description, one cannot expect to do much better than the experts in the WHO studies (Table 10.15).

Tortuosity of the Arterioles

If the retinal arterioles are subjected to chronic moderate hypertension, they will no doubt become tortuous, like a garden hose, occluded at the nozzle, which twists and becomes ectatic when the luminal water pressure is up. This has been demonstrated in Japanese studies using a fundus camera and measures of the curvature of the vessels, a technique that does not currently lend itself to bedside clinical examination.

Such "soft curves" of the arterioles, which looked as if they were too long for the veins and tended to cross the veins at right angles, were described in 14% of 500 hypertensive subjects (Bechgaard et al., 1950). The same workers found this sign present in only 2 of 124 normotensive subjects (Vogelius and Bechgaard, 1950). (This is probably the same as the Salus S which Salus thought was diagnostic

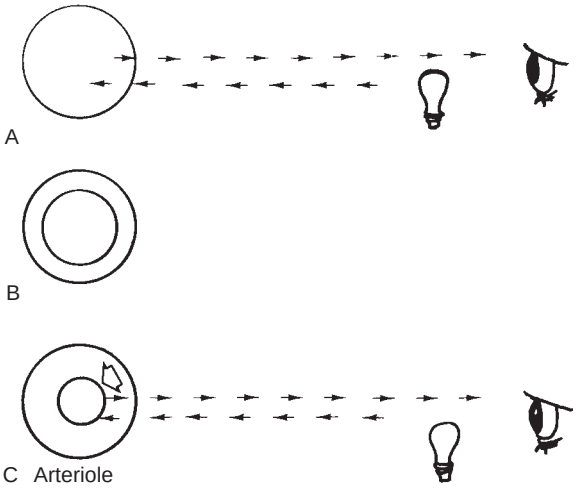


Figure 10-27 Cross-sectional diagrams of retinal arterioles. **A:** A normal arteriole. Light rays penetrate the thin vessel wall, illuminate the blood column within, and return to the observer's eye. **B:** The copper wire vessel has an intermediate degree of wall thickening. The reflected red light is made up partly of reflected silver light and partly of light from the blood column, which combine to produce a shiny orange or copper color. **C:** The arteriolar wall is so much thickened that the light rays cannot reach the column of blood within. Instead, the thick, scarred arteriolar sclerotic vessel acts as a mirror, reflecting pure white light back to the observer, who sees a silver vessel. The reflecting surface is probably that between the vessel lumen and the interior vessel wall (see the *hollow-headed arrow*), explaining the relative "narrowing" of the silver wire. (From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30:1–64, with permission)

for hypertension; the arteriole is "banked" as it crosses over the vein and so describes the letter S.)

This sign of chronic moderate hypertension is the only one not dependent on the pathologic process of arteriolar sclerosis, and so it is potentially the most useful for distinguishing the hypertensive fundus from the normotensive but aged one.

Focal Narrowing of Arteriolar Blood Column

Focal or localized narrowing of the arteriolar blood column is another of those findings that stumped the experts (Table 10.15). Furthermore, despite the trouble taken above to distinguish atherosclerosis and arteriolar sclerosis, this is one finding that can be due to atherosclerosis (Scheie, 1953), especially if the narrowing is eccentric. This has been proved by histopathologic examination of the previously photographed fundus, an opportunity that arises when a hypertensive patient must undergo enucleation for some other reason.

Diffuse Arteriolar Narrowing

Diffuse arteriolar narrowing is another source of difficulty. Fundus photographs have shown that after the infusion of vasoactive substances the retinal arteriolar blood column can undergo a reversible narrowing (Dollery et al., 1963). Thus, arteriolar narrowing could be seen in the fundus of the acutely hypertensive patient who has not yet developed arteriolar sclerosis (see also the discussion of the two retinopathies of hypertension, below). Furthermore, most of us do not obtain fundus photographs with measuring grids for comparison with baseline. Without such an objective measure, we cannot expect to do any better than the WHO experts (Table 10.15).

The attempt to estimate this diffuse narrowing from the ratio of the diameters of arteriole and venule (the arteriovenous ratio [AV ratio]) is also fraught with problems. A review of the literature revealed that a wide variety of AV ratios had been proffered *ex cathedra*. Unfortunately, they were so different (varying from 2:1 to 3:2, 4:3, and 5:4) that all of them could not possibly have been correct, even if one had been experimentally determined (which was not done). In fact, there is considerable normal variation in the anatomy of the retinal vasculature. Additionally, even given a situation in which the AV ratio was clearly abnormal in the judgment of all observers, how could one know that the arteriolar diameter was the abnormal one? There are many circumstances in which the retinal veins become engorged (Table 10.18). Furthermore, a Scandinavian study reported a 6% prevalence of venous engorgement in hypertensive men and a 2% prevalence in hypertensive women (Bechgaard et al., 1950). These findings were separate from the higher than normal prevalences of arteriolar narrowing reported in the same paper. As no fundus camera was used in this study, it is not clear to me how the ophthalmologist could, in the case of an increased AV ratio, know whether the arterial blood column was small or the venous blood column was enlarged. Furthermore, even if such judgments were made with a camera, what would the criteria for normality be? One should remember that a 5% prevalence of a finding such as arteriolar narrowing could be expected if the common definition of normality (± 2 standard deviations from the mean) is used.

TABLE **10.18** *A partial list of reported etiologies of retinal venous engorgement*

- Hematologic diseases
- Sickle hemoglobinopathies (10%–96%), other severe anemias, Waldenström macroglobulinemia, cryoglobulinemia, multiple myeloma, thrombotic thrombocytopenic purpura, polycythemia, leukemia (33%), lymphoma, hereditary hemorrhagic telangiectasia
- Metabolic diseases
  - Fabry disease, diabetes mellitus
- Infectious diseases
  - Scrub typhus (67%), Rocky Mountain spotted fever, murine typhus, lymphogranuloma venereum
- Congenital heart disease
- Internal carotid-cavernous sinus aneurysm
- Coarctation of the aorta
- Dermatomyositis
- Cystic fibrosis
- Behçet syndrome
- von Hippel–Lindau syndrome
- Wyburn–Mason disease
- Stasis retinopathies
- Arterial
  - Internal carotid occlusion
  - Takayasu disease
- Venous
  - Retinal vein occlusion
  - Increased intracranial pressure
  - Superior vena cava syndrome
  - Congestive heart failure
  - Cardiac tamponade
  - Tricuspid stenosis
- Hypertension (see text)

From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30: 1–64, with permission.

Plaque of Hollenhorst

Up to this point, we have been concentrating on the funduscopic signs of arteriolar sclerosis, noting that these may be clearly distinguished from atherosclerosis with the occasional exception of focal and eccentric narrowing of the blood column. There is, however, one true sign of atherosclerosis that cannot possibly be confused with arteriolar sclerosis: the plaque of Hollenhorst. This is a glistening, golden-yellow fixed spot in the arterial blood column, which, as its name implies, was once thought to be an atheroma. Actually, all or most of them are not plaques arising in situ but are cholesterol emboli from an ulcerating atheromatous plaque in the ipsilateral carotid (Brownstein et al., 1973; Pfaffenback and Hollenhorst, 1973).

The Hollenhorst plaque is 11% sensitive for the detection of occlusive disease. Patients with this finding succumb to either myocardial infarction or stroke at a much higher rate than the

age-matched population; their 10-year survival rate is only half that expected (Pfaffenback and Hollenhorst, 1973).

The Hollenhorst plaque is 11% sensitive for the detection of occlusive disease of the carotid system. It is 4% sensitive for the detection of vertebrobasilar disease, not because the vertebrobasilar system serves the fundus (it does not) but rather through common atherosclerotic involvement. The Hollenhorst plaques may also appear during 14% of carotid endarterectomies (Hollenhorst, 1961).

A perfect distinction between cholesterol emboli and plaques arising *in situ* is sometimes possible. As an atheroma can only arise in an artery, we need to ask ourselves where the retinal arteries are. Remembering that the retinal artery must by definition have a recognizable muscularis layer, we learn that only the retinal arterial vasculature very near the disc is truly arterial; the remainder is arteriolar. Thus, plaques of Hollenhorst at the periphery and not near the disc must be embolic. This is easy to visualize because many of these are lodged at bifurcations or are wedged into the arteriolar lumen of ever-decreasing diameter. Similarly, an eccentric plaque in a true retinal artery near the disc, which is too small to be wedged into place and is clearly growing on the side of the vessel wall, is probably a true atheromatous plaque (Fig. 10-24, right-hand panel). A backlit plaque (Fig. 10-24, middle panel) might be an atheroma. However, if it appears to be wedged into the retinal artery at a bifurcation or if it is seen moving through the arterioles, it is undoubtedly a plaque of Hollenhorst.

The patient with a plaque of Hollenhorst may tell you that he woke up blind in one eye or suddenly lost half of his vision. An initial suspicion of retinal detachment is disproved by examining the fundus, which appears pale and may reveal the plaque of Hollenhorst. Listen to the carotids (see Chapter 18) and consider carotid ultrasound. Aspirin therapy or other immediate intervention may be indicated.

Other Emboli

White plaques moving through the retinal vasculature may be platelet emboli or valvular emboli from rheumatic, marantic, endocarditic, or myxomatous disease (Sapira, 1984). One might also see tissue emboli from cardiac neoplasms, foreign microdispersoids (Lee and Sapira, 1973), or fat emboli from long bone fractures, which have found their way to a retinal arteriole. In patients exposed to blast, air may be seen in the retinal artery (Phillips and Zajtchuk, 1989). This finding, photographed in a sheep exposed to intense blast, suggests that the traumatic brain injury that is the signature injury of the Iraq war could be a form of decompression sickness.

Other Changes in the Retinal Vasculature

"Box-carring" and "Sausaging"

"Box-carring" refers to the segmentation of the blood column within the vessel (Fig. 10-28). It obviously requires that there be no motion within the vascular tree and is therefore a valid sign of death (i.e., the cessation of cardiac function).

"Sausaging" of the veins is a hallmark of macroglobulinemia, although it is also seen in other hyperviscosity syndromes. The vein swells in diameter between arteriovenous crossing points and thus resembles a string of sausages (more like bratwurst, knackwurst, or boudin than andouille).

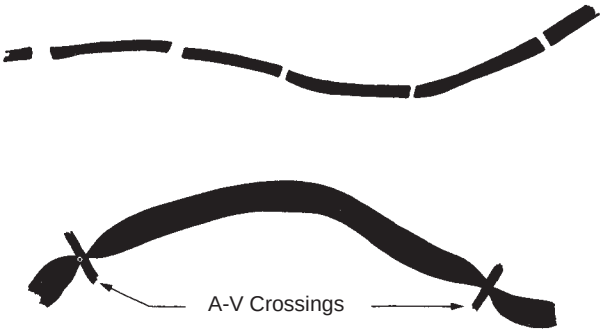


Figure 10-28 Above, box-carring. Below, sausaging of the veins.

Sheathing

Sheathing may be arteriolar or venous and refers to the appearance of a pair of white stripes on either side of the blood column, as if it were a red or purple highway (seen from above) with sidewalks alongside. Causes of sheathing are given in Table 10.17. Arteriolar sheathing is the most common retinal vessel abnormality in sickle hemoglobinopathy, occurring in 51% of children with hemoglobin SS and in 30% of children with hemoglobin SC (Talbot et al., 1982).

Venous Sheathing in Multiple Sclerosis

In 34 patients with otherwise unexplained perivenous sheathing, 21 received a diagnosis of multiple sclerosis and 7 more were suspected of having that diagnosis. On the basis of the number of patients with multiple sclerosis seen at the Mayo Clinic over the corresponding period, it was estimated that about 10% of such patients might display evidence of perivenous sheathing if a careful search was made for it (Rucker, 1944; Franklin and Brickner, 1947). Others estimated the prevalence to be from 9% to 36%. The sheathing is thought to result from retinal phlebitis. Fluorescein angiograms show leakage and thus increased permeability of the blood–retinal barrier.

CNS perivascular cuffing is arguably an initial event in plaque formation. Plaques have been shown to extend along the longitudinal course of a vein. While the occurrence of retinal phlebitis does not prove that CNS vascular cuffing is a primary event in plaque formation, it is intriguing that the phlebitis occurs without the presence of myelin or myelin-forming cells. Interestingly, venous sheathing has not been seen in experimental allergic encephalomyelitis, which some have considered a possible model for multiple sclerosis (Kerrison et al., 1994).

Theories to explain the pathogenesis of multiple sclerosis will need to explain the phenomena that occur in the eye, which is part of the CNS. These include retinal arteriolar constrictions associated with scotomata and reduced visual acuity that responded to vasodilating drugs (Franklin and Brickner, 1947; James, 1982).

Light Spots on the Retina

Cotton Wool Exudates

The name for these fluffy, nonglistening, pale white (to gray) spots derives from their generally fuzzy appearance and nondiscrete borders (which distinguish them from the "hard exudates,"

described below). Cotton wool exudates (also called *soft exudates*) are actually not white blood cell exudates but rather microinfarctions of the retina. Histologically, they are called "cytoid bodies." Their size varies up to 1 mm in diameter (Table 10.9). There are many causes of cotton wool exudates, some of which are listed in Table 10.19.

Cotton wool exudates are important for two reasons:

1. They are never normal, so their presence encourages a search for the underlying diagnosis. (However, as should be apparent from Table 10.19 and contrary to what is suggested in many texts, cotton wool exudates are not diagnostic for any one or even two diseases.)
2. In patients whose diagnosis has already been made, cotton wool exudates are special in their ability to reveal the vasculopathic severity of the disease in that individual patient.

TABLE **10.19** *Some causes of cotton wool exudates*

- All types of acute severe hypertension
  - Renal disease, vasculopathic
  - Toxemia of pregnancy
- Collagen vascular diseases (even without hypertension)
  - Systemic lupus erythematosus (3%–28% of cases)
  - Polyarteritis nodosa
  - Progressive systemic sclerosis (even without renal disease)
  - Dermatomyositis (especially in children, rarely in adults)
  - Wegener granulomatosis
- Infections
  - Septic retinitis (including bacterial endocarditis)
  - AIDS[a] (Newsome et al., 1984)
  - Chorioretinitis (Table 10.21)
- Diabetes mellitus (especially accompanied by hypoglycemia, hypertension and/or nephropathy)
- Conditions that cause papilledema (see text and Table 10.10); increased intracranial pressure, even before papilledema appears
- Stasis retinopathies (see text and Table 10.27)
- Microembolization
  - Intravenous drug abuse
  - Post cardiac surgery
  - Fat embolism or Purtscher retinopathy (see text)
- Adult anemia, when the hemoglobin is <6.6–8.0 g/dL (up to 33% of cases from some historical epochs)
- Neoplasia
  - Leukemia
  - Carcinomatosis
  - Hodgkin disease
  - Eales disease
- Pseudoxanthoma elasticum
- Posthemorrhagic retinopathy (see text)

[a]AIDS causes a microvascular disease apparent in the fundus and not related to ocular candidiasis, cytomegalovirus, or toxoplasmosis.
From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30: 1–64, with permission.

Hard Exudates

Hard exudates are proteinaceous (or sometimes lipoproteinaceous) deposits due to transudation (as in "albuminuric retinitis"). This results from a breakdown of the blood–retinal barrier so that serum leaks within the retina. Rarely, hard exudates are revealed after the resorption of (previously identified) hemorrhages. Hard exudates have discrete borders. They vary in color from yellow all the way to pure white. They often resemble candle drippings in that they are shiny like wax or soap. Sometimes they are arranged about the macula like the spokes or the rim of a wagon wheel (or a portion of such a wheel); in that case, one can be certain that they are indeed hard exudates. This pattern, which may be seen in hypertension, papilledema, papillitis, or central retinal vein occlusion, is sometimes called a *macular star*.

Hard exudates should suggest the presence of severe albuminuria, until proven otherwise. They are seen in severe hypertension and in renal disease with or without hypertension (and sometimes without proteinuria). They are also seen in 10% of severe cases of diabetes mellitus. A partial list of etiologies is given in Table 10.20.

Like soft exudates, hard exudates are never normal. They are most useful for evaluating the progress and severity of a previously diagnosed disease in the *individual* patient.

TABLE **10.20** *Some common etiologies of hard exudates*

- Severe hypertension, especially with renal disease
- Renal disease
- Severe diabetes mellitus, especially with renal disease
- Infections
- Measles, influenza, meningitis, erysipelas, psittacosis, parasitic infections, coccidioidomycosis, candidiasis, chronic syphilis, tuberculosis
- Collagen vascular diseases
- Normotensive dermatomyositis, Behçet syndrome, polyarteritis nodosa, systemic lupus erythematosus (<13%), progressive systemic sclerosis, "rheumatic polyarthritis"
- Hematologic diseases
  - Pernicious anemia, other severe adult anemias (hemoglobin <8 g/dL), multiple myeloma, leukemia
- Eye diseases
  - Disciform macular degeneration, Coats disease, Eales disease
- Cerebral trauma
- After strangulation
- Fat embolism
- Lead poisoning
- Old central vein thrombosis
- Papilledematous states
- Sarcoidosis
- Hypercholesterolemia, especially with nephrotic syndrome[a]
- Residual of prior hemorrhage (Tables 10.25 and 10.27)

[a]It is not clear from the literature that hypercholesterolemia ever causes hard waxy exudates in the absence of renal disease.
From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30: 1–64, with permission.

Pseudoexudates

Pseudoexudates are fundus lesions that are neither hard nor soft exudates but that visually could be confused with either. Causes of pseudoexudates are given in Table 10.21. The most important of the pseudoexudates is chorioretinitis.

Chorioretinitis

Chorioretinitis can be easily confused with exudates, especially at the most important time—when it is still in the acute stage and has not yet acquired the distinctive black pigmentation of the chronic stage. (Cotton wool exudates and hard exudates do not have black pigmentation.)

The selection of the causes listed as major is somewhat arbitrary. For example, *Onchocerca* infections blind 3% to 5% of the 20 to 40 million persons infected but are not a problem in the United States. Conversely, *ocular histoplasmosis* is most common in those portions of the US where the systemic disease is endemic but is rarely the cause of a similar retinal picture in the experiences of European workers.

TABLE **10.21** *Some etiologies of pseudoexudates*

Chorioretinitis

Major
- Histoplasmosis
- Tuberculosis
- Toxoplasmosis
- Syphilis
- *Onchocerca volvulus*
- Sarcoidosis
- Laser therapy for diabetic retinopathy

Minor
- Other parasites, e.g., *Toxocara, Leptospira interrogans, Entamoeba histolytica*
- Other fungi, e.g., *Sporotrichosis, Candida, Coccidioides, Cryptococcus*
- Other bacteria, e.g., *Brucella, Mycobacterium leprae*
- Rickettsial diseases, e.g., typhus, Q fever, boutonneuse fever
- Other viral infections, e.g., herpesvirus, cytomegalovirus, chicken pox, measles, influenza, Rift Valley fever

Other pseudoexudates

Major
- Drusen
- Myelinated nerve fibers

Minor
- Leukemic infiltrates
- The phakomatoses (Table 10.23 and Fig. 10-1)
- Choroidal tumors
- Metastatic tumors

Rare
- Secondary oxalosis
- Fundus xerophthalmicus (vitamin A deficiency)
- Thrombosed microaneurysm

From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30: 1–64, with permission.

The ophthalmoscopic features of histoplasmosis are (a) white to yellowish lesions, (b) a grouping of the lesions right around the disc, (c) peripapillary atrophy, (d) macular hemorrhage that can evolve into macular degeneration, and (e) equatorial streaks in about 5% of cases. The last are perfectly even bands or stripes thought to result from the coalescence of multiple lesions. But there is still no explanation for their perfect geometry. Despite their rarity, they are important because they may be pathognomonic for histoplasmosis. If the lesions are active, the patient has profound visual loss.

In young persons, histoplasmosis is the most common cause of a breach in Bruch membrane, resulting in neovascularization from choroidal vessels and hemorrhage beneath the retinal pigment epithelium. (In older persons, the most common cause is senile macular degeneration.)

Choroidal tubercles can be single and unilateral or multiple and of varying size. Although not clustered around the disc as tightly as the lesions in histoplasmosis, they still are often found within only 5 mm of the disc (a little more than 3 disc diameters). Also, although they are found in less than one third of cases of pulmonary tuberculosis, choroidal tubercles are stated to be present in more than half the cases of miliary tuberculosis. They are often of great diagnostic utility because they appear quite early in the miliary disease.

Acquired *toxoplasmosis*, when acute, produces a white lesion that is not located near the disc. When congenital, the lesions are usually bilateral, pigmented, and large (>1 mm), with small satellite lesions surrounding the larger ones.

Syphilis often, but not always, has a salt-and-pepper appearance of the fundus, especially in the congenital form.

Sarcoidosis is shown in Fig. 10-29. The retinal findings are the most classic of all the eye signs of sarcoidosis. The patient whose fundi are shown was found to have granulomas, which might have been

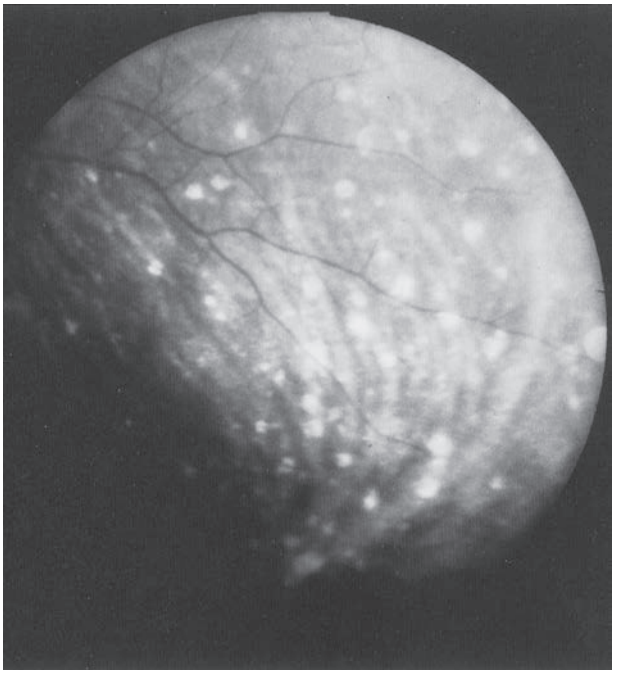


Figure 10-29 Classic retinal findings of sarcoidosis. Recognition of these findings might have saved this patient a liver biopsy (Table 10.22).

TABLE **10.22** *Eye findings in sarcoidosis*

Koeppe iris nodules
Conjunctivitis
Corneal scarring
Band keratopathy (due to the hypercalcemia)
Keratoconjunctivitis sicca (from lacrimal gland involvement)
Ocular palsies
Anterior uveitis (sometimes nodular)
Vitreous opacity in the dependent vitreous, sometimes seen as a string-of-pearls shadow on the lower retina
Retinal hemorrhages
Posterior uveitis, including the retinal granulomas shown in Fig. 10-29
Periphlebitis with venous sheathing
Disease of the optic nerve from simple optic neuritis to papilledema or optic nerve atrophy (Chumbley, 1981).

due to any one of the 14 causes, on liver biopsy. The fundal findings clinched the diagnosis. Such sarcoid tubercles, which are clearly neither hard nor soft exudates, may eventually progress to black scars. (Table 10.22 for a syllabus of Sarcoidosis.)

Drusen

Drusen are little clusters of discrete white, yellow, or gray spots, which are actually excrescences on the Bruch membrane. (Drusen, the German word for "glands," was apparently chosen because these little dots resemble apocrine glands.) They are very small, beginning at about 10 μm. In most cases, they do not indicate any underlying ocular or systemic disease and do not have the more serious significance of true exudates.

Drusen, especially when grouped around the posterior pole, can be an adumbration of senile macular degeneration in the elderly. They may be seen as a degenerative phenomenon (after Duke-Elder) occurring secondary to a number of diseases such as pseudoxanthoma elasticum, Bloom syndrome, Rendu–Osler–Weber disease, scleroderma, recurrent polyserositis, chronic leukemia, lipoid proteinosis, dysproteinemia, and phthisis of all causes. Still, in most clinical situations, drusen are of no diagnostic importance.

Myelinated Nerve Fibers

Myelinated nerve fibers, also known as *medullated nerve fibers*, have already been discussed in connection with pseudopapilledema. They resemble cotton wool exudates only in that they are white and may obscure an underlying retinal vessel.

Minor and Rare Causes of Pseudoexudates

Leukemic infiltrates are yellow, white, and/or gray and are heaped up in masses. Like the phakomatoses (Table 10.23), they may obscure the retinal vessels, whereas the large choroidal tumors and metastatic tumors do not. All of the minor group of pseudoexudates are relatively large lesions, compared with those lesions described as rare in Table 10.21. The latter are scattered about as tiny yellow crystals in the case of secondary oxalosis and as white spots in the other two cases. The fundus xerophthalmicus occurs in 20% to 46% of patients with vitamin A deficiency; the white spots are beneath the vessels and spare the macula.

TABLE **10.23** *The phakomatoses*

Eponym	Description
von Recklinghausen disease	Neurofibromatosis (Fig. 10-1)
Bourneville disease	Tuberous sclerosis (epiloia)
Sturge–Weber syndrome	Encephalotrigeminal angiomatosis (port wine stain)
von Hippel–Lindau disease	Cerebelloretinal angiomatosis
Louis–Bar syndrome	Ataxia telangiectasia (with immunodeficiency)
Wyburn–Mason disease	Encephaloocular arteriovenous fistulae or angiomas

Black Spots

Healed Chorioretinitis

The acute lesions of chorioretinitis, which are white or yellow, have been described above. However, with the passage of time, the chorioretinitis from any of the causes listed above will begin to heal. Then, previously unseen cells from the retinal pigment epithelium will migrate into the lesion. It is these cells, normally pigmented, but not usually visible, that produce the startling black appearance of old chorioretinitis. Despite their ominous appearance, the lesions do not interfere with vision unless they happen to involve the macula.

The round, regular, isometric pigmented scars of laser photocoagulation are so characteristic that their recognition should not be a problem, provided that one remembers to look through dilated pupils. The patient's history confirms the diagnosis.

I was once fooled in a case of laser photocoagulation (Fig. 10-30) by breaking my own rules: (a) never accept the findings of another examiner and (b) never examine through undilated pupils (unless unavoidable). I was told that the patient had a single white exudate, and I foolishly agreed to look through undilated pupils. I then saw a single white lesion near the disc, which I thought was the "single lesion" the house staff had seen, so I discussed the diagnosis of histoplasmosis (compare with the description discussed above). When the pupils were correctly dilated, however, the picture shown in Fig. 10-30 was revealed. (Because some of the lesions were fresh, they were still white.) The erroneous diagnosis of histoplasmosis thus suggested for this patient from the endemic zone of riparian Missouri could have been avoided if only the pupils had been dilated! (Oddly enough, the patient had no recollection of the laser therapy.)

Retinitis Pigmentosa

Many peripheral black spots, arranged in the shape and aggregation of bone spicules, are characteristic of retinitis pigmentosa (Heckenlively and Ellis, 1984). The term is a misnomer because the syndrome is not an infection or an inflammation but rather a

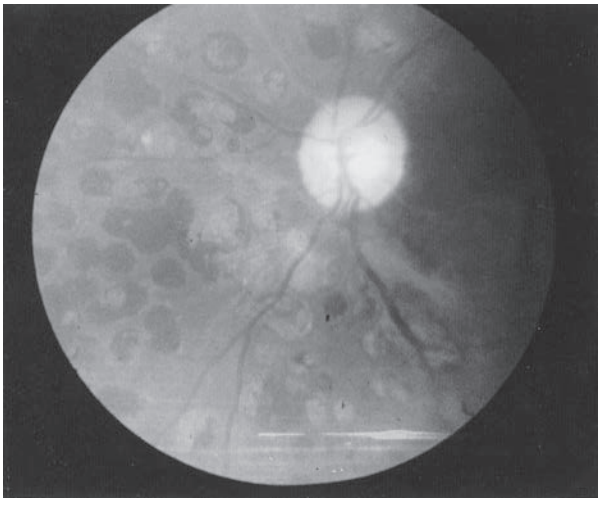


FIGURE 10-30 The scars of laser photocoagulation (see text).

degenerative process. Furthermore, in about 10% of the cases, there is a lack of pigmentation. In some cases, the most prominent finding is the choroidal degeneration that permits the choriocapillaris and/or the choroidal blood vessels to appear in the fundus view, just as with choroidal "sclerosis" (as discussed earlier in this chapter).

There are at least five or six forms of retinitis pigmentosa that are considered "primary," that is, without known etiology, although about half are familial and of an autosomal inheritance. In addition, retinitis pigmentosa is said to be secondary to about 20 known diseases.

Unless the patient has one of the few medical diseases for which effective therapy is available (e.g., vitamin A deficiency), this retinal condition is untreatable. Thus, ironically, the only treatable cases of retinitis pigmentosa are those that must be discovered by the primary physician. Usually, by the time the patient comes to the attention of the ophthalmologist, nearly all peripheral vision, and in some cases central vision, is already gone.

A high incidence of maculopathies has been found in cases of retinitis pigmentosa, from 60% to 94% (Chachia et al., 1987).

Retinal Pigment Epithelium Hypertrophy

Retinal pigment epithelium hypertrophy results in discrete black-to-brown, round, oval, or kidney-shaped spots, ranging in size from 0.15 to 1.5 mm or more, usually bilateral. Small (<0.15 mm) bilateral or unilateral lesions may be seen in normal controls, but no control ever had a total of more than four lesions.

These spots are a useful sign of Gardner syndrome. Using bilaterality and multiplicity (more than four) as criteria, it was found that the spots were 78% sensitive and 95% specific (Traboulsi et al., 1987). Colorectal carcinoma develops in 100% of patients with Gardner syndrome, which also includes colonic polyposis, benign soft tissue and bone tumors, dental abnormalities, extracolonic cancer, and desmoid tumors. The syndrome is inherited as an autosomal dominant.

The fundal lesions are not seen in Peutz–Jeghers disease, which has a very low potential for malignant degeneration.

Choroidal Hemorrhages

Choroidal hemorrhages occur behind the pigment layer. Therefore, instead of being red, they appear to be purple, black, or gray. Some have imitated a malignant melanoma so well that the eye was enucleated. A valuable clue, in addition to the color, is that the retinal vessels will always cross over the top of this type of hemorrhage. The reason for this can best be understood by reviewing the sagittal section of the fundus shown in Figure 10-31.

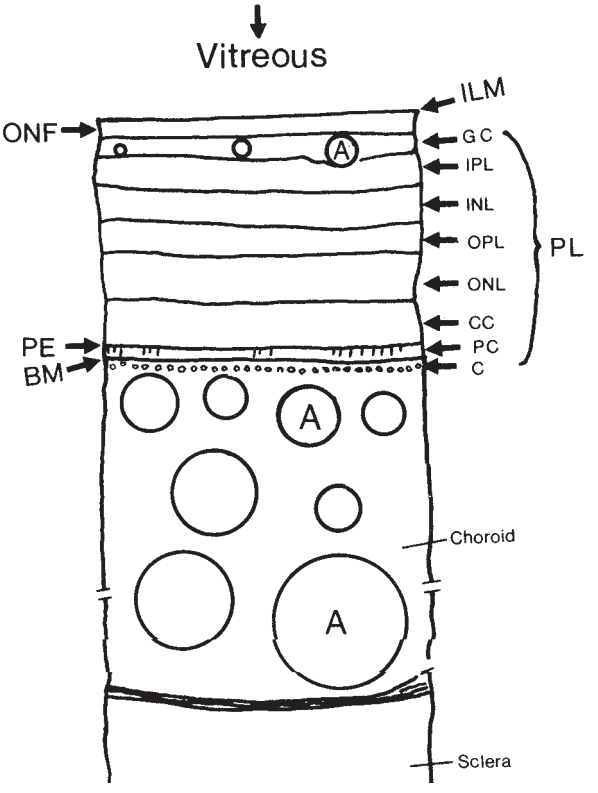


FIGURE 10-31 A schematic sagittal section of the posterior pole: the arrow at the top indicates the axis of inspection. Starting from the bottom of the diagram, we move anteriorly, or inwardly. First comes the sclera; then the choroid with artery A. C, represents the small choriocapillaris, which is the smaller choroidal vasculature that best imitates angioid streaking in choroidal thinning. BM is Bruch membrane, also known as the *lamina vitrea*, the anterior delimitation of the choroid. This is where angioid streaks and drusen occur. PE is the pigment epithelium. Only hemorrhages anterior to this layer will appear red. PC denotes the pigment cells. The next six layers are the connecting cilium (CC), the outer nuclear layer (ONL), the outer plexiform layer (OPL), the inner nuclear layer (INL), the inner plexiform layer (IPL), and the ganglion cell layer (GC). These are collectively labeled PL, or parallel layers. This is to emphasize that hemorrhages in these layers will tend to align themselves along the nerve fiber layers in an axis parallel to the axis of inspection, producing blot hemorrhages. The round structures lying among the ganglion cells, one of which is labeled A, are retinal arterioles in cross section. As the peripheral arterioles and venules tend to lie in the ganglion cell layer, it becomes obvious that hemorrhages posterior to this layer will not obscure these larger vessels and that hemorrhages in layers anterior to these vessels must always obscure them. ONF is the optic nerve fiber layer (also called the *inner nerve fiber layer*), or stratum opticum. Here the nerve fibers run perpendicular to the axis of inspection so that hemorrhages between nerve fiber bundles will appear splinter- or flame-shaped. ILM is the internal limiting membrane that holds back preretinal or subhyaloid hemorrhages. Hemorrhages that burst through the internal limiting membrane anteriorly would become subhyaloid (preretinal). If they could next penetrate the hyaloid membrane (not shown but immediately anterior to the internal limiting membrane), they would become vitreous hemorrhages. (From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30:1–64, with permission.)

These hemorrhages come from the choroidal vessels, not from the retinal vessels, and so do not necessarily result from the same etiologies (*vide infra*) as the hemorrhages that are discussed later. Etiologies include, but are not limited to, subarachnoid hemorrhage, chorioretinitis, polyarteritis of the choroidal (not retinal) vessels, thrombotic thrombocytopenic purpura, leukemia, *E. histolytica* brain abscess, pernicious anemia, diabetes mellitus, Paget disease, and eye diseases including senile macular degeneration (Sapira, 1984).

Melanomas

Melanomas present as raised black lesions. Melanomas may appear to be less black and more grayish if they are choroidal (behind the pigment layer) and not retinal. Amelanotic (white) melanomas are as unusual in the fundus as they are elsewhere. Melanomas are lethal but are rare in the retina.

Benign Choroidal Nevi

Benign choroidal nevi are common. They are light gray to black, flat, and usually circular. They are to be distinguished from melanomas.

The Benign Melanocytoma

The benign melanocytoma, a black dot characteristically located on the nerve head, may be seen in black patients.

Congenital Hypertrophy of the Retinal Pigment Epithelium

It is important not to confuse congenital hypertrophy of the retinal pigment epithelium with a malignant melanoma. It is a round, flat, darkly pigmented lesion with sharp borders, usually unilateral. It may be 1 to 2 disc diameters in size and may appear at any position in the retina. Several punched out holes are commonly seen within it.

Red Spots

Microaneurysms

Capillary microaneurysms (Fig. 10-32) are small, perfectly round, red dots, with distinct edges, 20 to 60 μm in diameter. They are most common near the macula. Capillary microaneurysms should be considered the result of diabetes mellitus until proved otherwise (Sapira, 1984). If they are unilateral, look for other vascular diseases; however, even if seen only in one eye, they may generally be demonstrated bilaterally on fluorescein angiography.

Microaneurysms have also been reported in up to 40% of cases of sickle cell disease and other sickle hemoglobinopathies and, rarely, in other anemias, when severe. They may also be seen in AIDS (Newsome et al., 1984). Very rarely, microaneurysms may be seen in bacterial endocarditis, in the other arterial or venous forms of stasis retinopathy, and in Coats syndrome. I have never seen them in uncomplicated hypertension. Actually, the ones that occur in hypertension and polyarteritis (pictured in Fig. V in Shelburne, 1965) are aneurysms of the arterioles. They look different from diabetic microaneurysms, which occur away from vessels, mostly in the perimacular area. I have seen microaneurysms in normoglycemic recovering addicts who could have been prediabetic (Sapira and Cherubin, 1975). In Scandinavia, they have been reported in unaffected relatives of diabetics and in one study were considered to be "idiopathic" (Sapira, 1984). Other very rare associations include posterior uveitis and loa loa infection (Sapira, 1984).

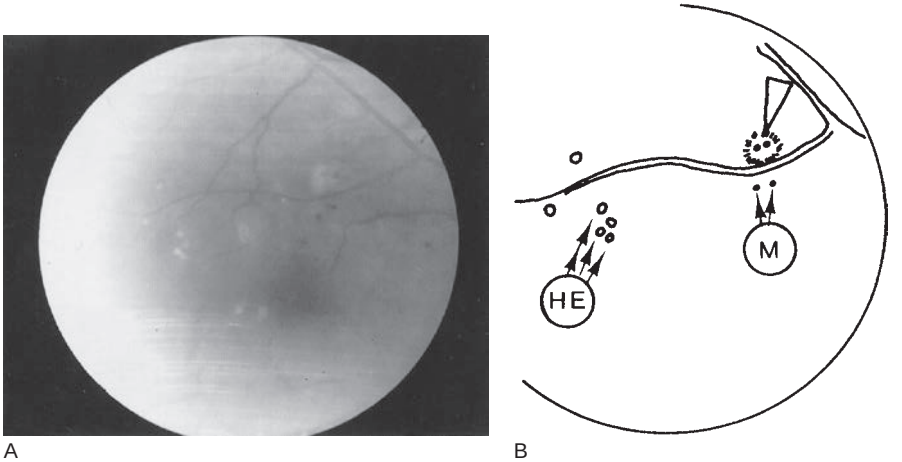
Blot Hemorrhages

Blot hemorrhages are the result of bleeding somewhere deep among the parallel layers of the sclera (Fig. 10-31). Blot hemorrhages are usually cylindrical but appear round when viewed "down the barrel." They vary in size from 100 μm to 10 times that large. If you initially have trouble distinguishing them from microaneurysms, remember that the latter are smaller, more perfectly round, and have a perfectly distinct border. Blot hemorrhages actually look like a blot. With practice, these differences become obvious, although even the "experts" did not clearly distinguish microaneurysms and blot hemorrhages until the 20th century. Some causes of blot hemorrhages are listed in Table 10.24.

There is also a subretinal hemorrhage that is just in front of the pigment epithelium and therefore red. It is called subretinal because it is under the parallel layers, and so instead of forming a blot hemorrhage, it may actually spread out and form a wide hemorrhage. The retinal vessels are, of course, always on top of this hemorrhage. It has the same significance as the blot hemorrhage.

Flame and Splinter Hemorrhages

Within the area seen by direct ophthalmoscopy, hemorrhages in the outer nerve layer may look like splinters or flames (see ONF in Fig. 10-31). The individual splinter is a line of blood pooling



A B

FIGURE **10-32** **A:** Above the large vessel crossing from right to left are two microaneurysms fortuitously backlit by an exudate. Below the vessel are more dark spots that were bright red in vivo. These were also due to diabetes mellitus. The light spots in the photograph are exudates; some look like discrete drops of wax, and others are softer in appearance. **B:** Diagrammatic representation of the fundus photograph. The *arrows* point to the two microaneurysms referred to above (the diagram resembles two fried eggs). HE, hard exudates; M, microaneurysms. (From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30:1–64, with permission.)

TABLE **10.24** *Some common causes of blot hemorrhages*

- Severe hypertension
- Sudden reduction of arterial pressure (Kaur and Taylor, 1990)
- Diabetes mellitus
- Collagen vascular disease
  - Systemic lupus erythematosus
  - Progressive systemic sclerosis (even without hypertension)
  - Dermatomyositis (even without hypertension)
- Intracranial hemorrhage (10%–40%)
- Stasis retinopathies, both arterial and venous forms (see text);
  - Hematologic disorders
  - Anemias (severe: hemoglobin <8 g/dL if no associated thrombocytopenia)
  - Aplastic (about 30%)
  - Pernicious, untreated (about 25%)
  - Iron deficiency (about 10%)
  - Hemolytic, specifically excluding thalassemia (about 10%)
    - Leukemia (about 33%)
    - Waldenström macroglobulinemia
    - Multiple myeloma (about 33%)
    - Myelofibrosis (<33%)
    - Polycythemia rubra vera
    - Thrombotic thrombocytopenic purpura
  - Other thrombocytopenia if associated with anemia (hemoglobin <12 g/dL)
- Infections
  - Bacterial endocarditis
  - Scrub typhus and other rickettsial diseases (5%–33%)
  - AIDS (Newsome et al., 1984)
- Sarcoidosis
- Amyloidosis
- Traumatic, including short-distance falls in infants (see text)
  - Strangulation
  - Decompressive barotrauma (caisson disease)
  - Posthemorrhagic retinopathy
  - Fat embolism
  - Other embolizations, as from talc in intravenous drug abuse
- Eales disease
- Purtscher retinopathy (see text)
- Extracorporeal membrane oxygenation (Pollack and Tychsen, 1996)
- Neonates after normal birth (see text)
- Cardiopulmonary resuscitation (see text)
- Raised central venous pressure (see text)
- Scurvy (see text)

From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30: 1–64, with permission.

between nerve fibers oriented with their long axes perpendicular to your axis of inspection. A larger collection of blood will have a flame-shaped or feathery edge; thus, the flame-shaped hemorrhage is just a coalescence of splinter hemorrhages.

TABLE **10.25** *Some common causes of flame or splinter hemorrhages*

- Dangerous hemorrhages
  - Splinter hemorrhages found only on or near the disc
    - Glaucoma
    - Papilledematous states
    - Increased intracranial pressure
    - Retinal vein obstruction
    - Subdural hematoma
    - Subarachnoid hemorrhage
  - Other emergencies
    - Intracranial hemorrhage (10%–40%)
    - Accelerated (malignant) hypertension
    - Posthemorrhagic retinopathy
- Additional causes
  - Any of the causes of blot hemorrhages (Table 10.24) can also cause flame or splinter hemorrhages
  - Polyarteritis nodosa
  - Behçet syndrome
  - Takayasu disease
  - Paget disease
  - Atrial myxoma
  - Uncomplicated thrombocytopenia (platelet count <50,000/mm^3)
  - Malnutrition

From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30: 1–64, with permission.

The causes of flame and splinter hemorrhages are listed in Table 10.25. *Splinter hemorrhages found only on or near the disc are always important.*

White-centered Hemorrhages

There are three common but erroneous beliefs (Sapira, 1984) concerning the white-centered hemorrhage (Fig. 10-33). The first is that its correct eponym is the "Roth spot." Roth, in 1872, did describe retinal red spots (previously described by Bowman), as well as retinal white spots, in septic retinitis (Roth, 1872), but he did not describe red spots with white centers in bacterial endocarditis or any other illness. The white-centered hemorrhage was first described in endocarditis by Litten in 1878, 6 years later.

Here, in the same sequence in which they published, are the two authors:

Roth, in 1872, discussing retinitis septica: "…*Kleine weisse Flecke in verscheidener Zahl, meist auf beiden Seiten, oder auch rothe Flecke*…" (Roth, 1872). ("…Small white spots in varying number, mostly on both sides or also red spots….")

Litten, in 1878, discussing the bilateral retinal hemorrhages seen in Charlotte Lewald, a day before she died of endocarditis: "*Viele von ihnen lassen in ihren Centrum eine helle weisse Stelle erkennen.*" (Litten, 1878). ("Many of these showed in the center a light white place.")

The second common erroneous belief is that the white-centered hemorrhage, by whatever name, is specific for endocarditis. This is not true, as shown by Table 10.26.

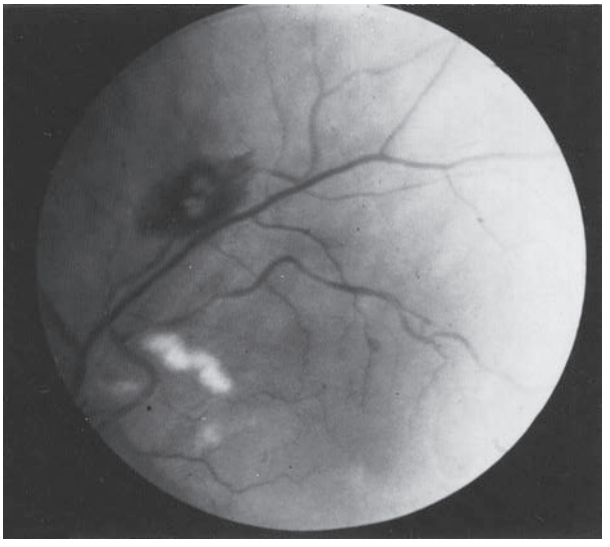


FIGURE 10-33 A flame hemorrhage with two white centers, from a patient who did not have infectious endocarditis. If you hold the misconceptions that these lesions should be called Roth spots, that they should have centers composed of white cells and microorganisms, and that they are diagnostic of endocarditis, please see the text. (From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30:1–64, with permission.)

The third erroneous belief is that the white centers are the result of the presence of white cells. However, except for the leukemias and some cases of bacterial endocarditis, the white centers are not white cells but fibrin (Duane et al., 1980; Mahneke and Videbaek, 1964; Van Uitert and Solomon, 1979). Accordingly, any flame-shaped hemorrhage could come from a vascular leak, which presumably could also leak protein and so permit the hemorrhage to become a white-centered hemorrhage (Litten spot). Thus, Table 10.26 is undoubtedly too short.

A red-centered white spot has been reported in neurodermatitis diffusa and bronchial asthma. I have also seen one in diabetes mellitus. Any blot hemorrhage surrounded by retinal edema could produce that same appearance, as could an exudate with a hemorrhage in the middle.

Shaken Baby Syndrome

In 2004, when an infant dies unexpectedly, its distraught and bewildered parents may find themselves immediately under suspicion or even under arrest. The police may seek a confession that someone shook the baby, say, in trying to revive it, before the person who discovered the infant has time to compose his thoughts. If the child is found to have retinal hemorrhages, the child's father, mother, or babysitter could be facing severe criminal penalties, up to life imprisonment.

The triad of a swollen brain, subdural hematoma, and retinal hemorrhages tends to be automatically attributed to shaken baby syndrome, with the name of the condition implying nonaccidental trauma. The act of vigorous shaking is said to tear blood vessels, especially bridging veins (American Academy of Pediatrics, 2001), and to shear the retina.

The American Academy of Ophthalmology states on its Internet site in March 2004, that "when extensive retinal hemorrhage accompanied by perimacular folds and schisis cavities is found in association with intracranial hemorrhage or other evidence of trauma to the brain in an infant, shaking injury can be diagnosed with confidence regardless of other circumstances."These findings, however, have been reported in a child who died after a television set fell on his head, without causing direct trauma to the eyes or orbits. Authors of the report (Lantz et al., 2004) reviewed the

TABLE **10.26** *Causes of white-centered hemorrhages*

- Infections
  - Endocarditis (may be embolic)
  - Other bacterial septicemias (may be embolic)
  - Rocky Mountain spotted fever
  - Kala azar
  - Candidiasis
  - Psittacosis
  - Typhoid fever
  - Viral infections
  - AIDS (Newsome et al., 1984)
- Hematologic diseases
  - Severe anemia
  - Multiple myeloma
  - Leukemia
- Cardiovascular diseases
  - Postcardiac surgery
  - Syphilitic aortitis
  - Rheumatic valvulitis
  - Hypertension
- Vasculitis, specifically including that due to systemic lupus erythematosus
- Neurologic disorders
  - Intraventricular hemorrhage
  - Ruptured arteriovenous malformation
  - Ruptured mycotic aneurysm
  - Ruptured nonmycotic aneurysm
  - Subdural hematoma
- Other
  - Metabolic
  - Diabetes mellitus
  - Scurvy
  - Hypoxia of mountain climbing
  - Carbon monoxide poisoning
  - Lung cancer with cyanosis retinae
- Posthemorrhagic retinopathy
- Neonatal birth trauma
- Battered children
- Difficult or prolonged anesthetic intubation
- Oral contraceptives
- Central hemorrhagic retinopathy

From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30:1–64, with permission.

literature from 1966 through 1998 for evidence of the specificity of perimacular retinal folds for abusive head injury. They concluded that statements concerning the diagnosticity of this finding were unsupported by scientific evidence. Articles in indexed medical publications were tainted by selection bias, inappropriate controls, and lack of precise criteria for case definition. "Many studies committed a fallacy of assumption, selecting cases by the presence of clinical findings that were sought as diagnostically valid."

The physician must consider the differential diagnosis of retinal hemorrhages (Tables 10.24–10-26). There are some special considerations for babies, discussed in Chapter 26 in the section on subdural hematoma.

Retinal hemorrhages are present in 20% to 50% of vaginally delivered newborns, almost exclusively in those delivered cephalad, and in only 0.8% of babies born by cesarean section (Goetting and Sowa, 1990).

Retinal hemorrhages may occur in falls considered to be minor. In children who fell from heights less than 10 ft, four of the six who had funduscopic examinations documented in the medical record had bilateral retinal hemorrhages (Plunkett, 2001). All of 26 children aged 13 months and younger who had acute subdural hematoma after minor head trauma, including a fall from a sitting position onto a Japanese mat, had retinal hemorrhage and semicircular preretinal hemorrhage around the discs (Aoki and Masuzawa, 1984).

Scurvy can cause retinal and intracranial hemorrhages. Vitamin C requirements are increased by illness or catabolic conditions (Hürlimann and Salomon, 1994).

In a study of 20 children who underwent cardiopulmonary resuscitation, 2 (10%) had retinal hemorrhages (Goetting and Sowa, 1990). Others have also reported this finding (Weedn et al., 1990), including one case in which absence of retinal hemorrhages prior to the arrest was documented (Kramer and Goldstein, 1993).

Raised central venous pressure from crying, seizures, straining, vomiting, or coughing can be associated with superficial retinal hemorrhages, which rarely have more than a transient effect (Kaur and Taylor, 1990).

Dilated fundus examinations should be done for sick babies and not just when a suspicion of child abuse is entertained. The location, extent, and severity of hemorrhages must be documented. A careful social history, precise details of any reported trauma, dietary history, drug and vaccine history, and a complete medical history with special attention to positive and negative findings pertinent to the differential diagnosis all need to be documented. Be aware of the probable forensic importance of these details.

Preretinal (Subhyaloid) Hemorrhage

Preretinal (subhyaloid) hemorrhages can arise by anterior extension of any retinal hemorrhage or from the etiologies listed in Table 10.27. There is now evidence that they can actually be in two anatomically different spaces. However, the preretinal and subhyaloid hemorrhages are of identical etiology and appearance, so the difference can be considered moot for our purposes.

Subhyaloid hemorrhages are frequently seen following ruptured intracranial aneurysms and occasionally after cranial trauma. The mortality rate of subarachnoid hemorrhage is 60% when these hemorrhages are present, compared to 27% when they are not, suggesting that their presence is related to the severity of the bleeding and of the elevation in intracranial pressure (Vanderlinden and Chisholm, 1974).

TABLE **10.27** *Some etiologies of subhyaloid and preretinal hemorrhages*

Any of the causes listed in Tables 10.24 or 10.25
Infectious diseases
Histoplasmosis
Pertussis
Ruptured diabetic neovascularization
Sickle hemoglobinopathies

From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30: 1–64, with permission.

Are preretinal hemorrhages round (as described by neurologists and neurosurgeons), or do they have straight tops (as illustrated in ophthalmology textbooks)? It depends on whether the patient is sitting or recumbent. Patients who are well enough to walk into the ophthalmologist's office will have their hemorrhage layer out. Thus, in the frontal view, they will have a straight edge superiorly, like a cup of borscht (a Russian beet soup served in a glass cup). However, if the patient has had a major vascular accident and is taken to the emergency room, his posterior pole hemorrhage will layer out and appear as a saucer of wine. This illustrates the rule: "What you see depends on where you stand"—or in this case, on whether the patient is able to stand. Note that regardless of whether the preretinal hemorrhage has the cup-of-borscht or the saucer-of-wine appearance, the retinal vessels are always obscured by the hemorrhage (Sapira, 1984).

For the Attending: The erect position is preferable for roundsmanship because with time the components of the blood begin to sediment, provided that the patient is not disturbed. Thus, the observant attending can not only make an estimation of the erythrocyte sedimentation rate, the size of the buffy coat, and the icterus index, but he can also occasionally estimate the degree of lipemia.

Vitreous Hemorrhage

The most anterior of the hemorrhages, the vitreous hemorrhage, can arise by extension from any preretinal or subhyaloid hemorrhage and so, by extension, from any flame or blot hemorrhage (see Fig. 10-31 for a review of the anatomy). The appearance can vary from a small amount of ill-defined blood to a mass of blood so large as to obscure even the red reflex. A vitreous hemorrhage is an indication that the ophthalmologist should be called immediately after making the patient lie down because an underlying retinal detachment may be present. As for determining the etiology, the most important information is the premorbid appearance of the fundus (i.e., before the vitreous hemorrhage obscured the view). This is another reason why all primary care physicians should perform and record baseline ophthalmoscopy regardless of the reason for the patient's initial physical examination.

The most common cause of a vitreous hemorrhage is a degenerative change limited to the eye, called a *posterior vitreous detachment*. The second most common cause is neovascularization due to a systemic

vascular disease. In 1884, Freud reported a vitreous hemorrhage in association with a subdural hematoma in a case of scurvy (Vanderlinden and Chisholm, 1974). Rarely, vitreous hemorrhage has been associated with subarachnoid hemorrhage secondary to rupture of an aneurysm; this is called *Terson syndrome* (Biousse et al., 1998).

The Macula

Cherry-Red Macula

The medical causes of a cherry-red macula are listed in Table 10.28. The cherry-red macula may occur with vascular syndromes because the macula receives a separate blood supply, permitting it to glow red against the pale ischemic background of the remainder of the fundus. Alternately, the remainder of the fundus may become pale, not from ischemia but from neuronal infiltration by the substances of the various storage diseases.

Macular Degeneration and Destruction

Macular degeneration is protean in appearance. It may simply appear, in white light, as an absence of the macula. The situation is more obvious in those degenerations in which the macula is replaced by drusen, scar, or pigment. It causes devastating loss of central vision, with preservation of peripheral vision.

A patient was presented as having a past history of blindness due to glaucoma, which supposedly had not been treated because he was thought to be cortically blind from an old stroke. Inexplicably, he claimed to have some vision remaining on the right. No one could place a lesion that would account for such a constellation of chart diagnoses, and after a fruitless 15 minutes of drawing visual pathways, someone decided to examine the patient.

The patient explained that he could still see objects on the periphery of the visual field of his right eye, a fact that had been misunderstood to mean hemianopia. Examination revealed that the patient had a direct pupillary response to light on the right (but not on the left), peripheral but no central vision on the right, and no vision on the left. The anterior chambers were not shallow, and the eyeballs were soft. So far, one could diagnose nonglaucoma and noncortical blindness, but there was no explanation for the peculiar findings, until the fifth physician to examine the patient on this one admission used the ophthalmoscope to find obvious old chorioretinitis, diffuse on the left and involving the maculae bilaterally.

For the Very Advanced Student. In patients whose macular degeneration is secondary to macular edema or cystoid macular degeneration, white light may reveal flecks, holes, honeycombing, or nothing, as noted above. However, in the last case, red-free light may reveal a rough, cobblestone-type of reflection in the area of the macula, which can be the first sign of macular degeneration of the honeycomb-type. Hemorrhages may be seen in the wet form, which constitutes about 5% of the cases of macular degeneration. Wet and dry forms cannot be reliably distinguished on direct examination; fluorescein angiography is required because the former may be slowed or arrested by special forms of laser or drug treatment.

TABLE **10.28** *Some causes of a cherry-red macula*[a]

The sphingolipidoses (including the gangliosidoses GM_1, type 2, and GM_2, type 2)
Retinal artery occlusion (or very severe arterial stasis retinopathy)
Mucopolysaccharidoses type VIII and IH
Temporal arteritis
Cryoglobulinemia
Traumatic retinal edema
Sandhoff disease
Hemorrhage at the macula, which has been misidentified
Severe hypertension
Quinine toxicity
Hallervorden–Spatz disease
Disseminated lipogranulomatosis
Cherry-red spot-myoclonus syndrome (Rapin et al., 1978)

[a]Full list in Roy.
From Roy FH. *Ocular Differential Diagnosis.* 3rd Ed. Philadelphia, PA: Lea & Febiger; 1984 (a comprehensive unillustrated listing of differential diagnoses of the eye, with no discussion of the lesions or estimation of their relative frequency), with permission.

Synthesis: Retinopathies

Stasis Retinopathy

Stasis retinopathy results from any condition that impairs venous drainage from the eye or that impedes arterial flow. The various etiologies are listed in Table 10.29.

Purtscher Retinopathy

Patients suffering severe trauma may experience a sudden loss of vision hours after the accident. The fundus shows the picture of Purtscher retinopathy: arterial spasm, retinal edema, cotton wool exudates, and hemorrhages confined to an area limited by the optic discs and macula. The changes may progress over several days and resolve slowly. Sometimes vision improves to a varying degree.

TABLE **10.29** *Some causes of stasis retinopathy*

Hyperviscosity syndromes
Multiple myeloma (6% of cases, especially with hypertension)
Cryoglobulinemia
Macroglobulinemia
Polycythemia
Sickle cell disease
Venous stasis (e.g., retinal vein occlusion)
Arterial occlusions (e.g., carotid occlusion [atherosclerosis]; Takayasu disease)
Embolization (e.g., fat emboli, specifically including pancreatitis; atheromatous emboli)

From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30: 1–64, with permission.

Purtscher retinopathy was originally described in patients who had sustained head trauma. The mechanism was thought to be a rapid rise in intravascular pressure caused by the force of deceleration. However, this retinopathy can also result from other types of trauma, including circumstances that cause a sudden increase in intrathoracic pressure: compression of the chest by shoulder safety belts, prolonged Valsalva maneuvers as in childbirth, and crush injuries (Goetting and Sowa, 1990). Embolism due to air, fat, or aggregates of granulocytes are the postulated mechanisms (Kincaid et al., 1982).

Purtscher retinopathy has also been reported in patients with acute pancreatitis. Here, complement-induced leukoembolization (Jacob et al., 1981) and/or fat emboli (Inkeles and Walsh, 1975) are thought to play a role. In fact, it is not certain that Purtscher retinopathy is anything more than the ophthalmoscopic part of systemic "fat embolism" (see Chapters 7, 16, and 26).

Hypertensive Retinopathies

There are actually two different types of retinopathy associated with hypertension (Table 10.30), the component parts of each having already been presented. The first type, called "neuroretinitis," is that of accelerated hypertension, including acute malignant hypertension or hypertensive crises of any etiology. It occurs without regard to the presence or absence of the other type of hypertensive retinopathy and may develop in a matter of hours or days. It can resolve in days or weeks, with resolution of the hypertension. The retinal findings reflect an acute generalized vasospasm. The findings that distinguish this type are the hemorrhages, exudates, and papilledema. However, only the hemorrhages are required to make the diagnosis, and the papilledema appears only after the hemorrhages and exudates, if at all. Of course, the findings (Fig. 10-34), individually and collectively, could also be due to some other process and must be interpreted in the light of the clinical picture, especially including the measurement of the blood pressure.

Normotensive patients who have experienced severe hemorrhage may acutely develop an ischemic retinopathy, complete with hemorrhages and exudates, which exactly resembles the neuroretinitis of accelerated hypertension (Pears and Pickering, 1960). This is called "posthemorrhagic retinopathy." The second hypertensive retinopathy, due to chronic moderate hypertension, has been called *arteriolar sclerosis*, an unfortunate term because it is also the name of the pathologic process that underlies most of the various ophthalmoscopic components. It takes years for the signs of arteriolar sclerosis to develop, and once they do, they never resolve. At this point, the sophomore should review the material under the heading Arteriosclerosis of the Retinal Arteries and Arterioles, discussed earlier in this chapter. To summarize, the hallmarks of arteriolar sclerosis are arteriovenous crossing changes, copper or silver wiring ("increased light reflex"), tortuosity of the arterioles, and diffuse arteriolar narrowing. (The last may also occur because of the vasospasm in the first type of hypertensive retinopathies. Focal narrowing can occur in both types as well.)

Note that the findings of arteriolar sclerosis may be seen in a fundus that also shows neuroretinitis, if the patient has the acute process of accelerated hypertension superimposed on chronic moderate hypertension. Conversely, a patient with newly occurring mild hypertension might have *neither* type of retinopathy.

TABLE **10.30** *The two retinopathies of hypertension*

Finding	Neuroretinitis	Arteriolar sclerosis
Type of hypertension	Acute, accelerated	Chronic, moderate
Hemorrhages	Usually	No
Exudates	Usually	No
Papilledema	Possible	No
Diffuse narrowing	Vasospasm	Yes
Focal narrowing	Vasospasm	Yes
Complete arteriovenous crossing changes more than 2 disc diameters away from the disc	No	Possible
Copper or silver wiring	No	Possible

From Sapira JD. An internist looks at the fundus oculi. *Dis Mon.* 1984;30:1–64, with permission.

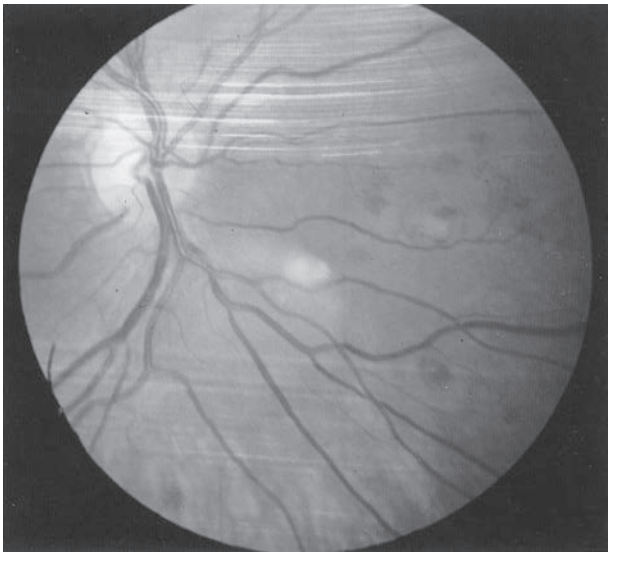


FIGURE 10-34 Many persons will diagnose this as hypertensive retinopathy, and some will bet on it (in case you are short of coffee money). For the record, this photograph is from an otherwise healthy 23-year-old drug abuser I cared for, who specifically had had no episodes of hypertension or any of the arteriosclerotic diseases. Furthermore, repeated follow-up photographs (not shown) documented the complete resolution of all the hemorrhages and exudates. Note that these changes are not specific. (The white-centered hemorrhages, which the observant reader may have spotted, are likewise nonspecific, see p. 229.) What disease caused these events, if not an acute hypertensive episode (Appendix 10.3)? To those who claim that there are arteriovenous crossing changes, we note that the distal changes are incomplete and the ones near the disc are perfectly normal, being found in about half of the normal population (see criteria, p. 219). Some think there is arteriolar narrowing; we refer them to page 222. (Photograph courtesy of Charles B. Slack, Inc, with permission.)

When Scheie distinguished the two retinopathies in 1953, he chose the unfortunate terms "hypertension" for one and "arteriolar sclerosis" for the other. He published diagrams of two different gradings at the same time. These were, for a time, reprinted in physical diagnosis textbooks without the long accompanying discussion or the histopathology. In this way, the wrong idea arose that the "hypertensive" changes were from hypertension and that the "arteriolar sclerosis" was *not* due to hypertension but rather came from atherosclerosis.

It will be noticed that no grading system from Roman numerals I to IV (although a tradition in texts of physical diagnosis) has been proffered. There are a variety of such systems, some of which combine the acute and chronic changes and some of which do not. The Scheie 1953 system, which separates the two, could be recommended, but it requires two gradings for each patient, and no one seems to do that any longer. The Wagener system of the 1930s was used to predict prognosis but would have to be adjusted each decade to allow for changes in prognosis because of improvements in therapy.

For the Attending. The two empiric patterns of neuroretinitis and arteriolar sclerosis are useful in the individual patient. Gradings, on the other hand, are statistical associations useful only for group prognostication. There are also other statistical associations. For example, hypertension is associated with senile macular degeneration in some studies (Sperduto and Hiller, 1986).

Diagnosticity of Hypertensive Retinopathy

How good are the experts at diagnosing hypertension from the examination of the fundus? Only two studies have attempted to answer this question in a blind fashion. In a European study performed before World War II, Salus (1958) had a sensitivity of 70%, with no false-positives. This stands as a world record. In a WHO study published in 1966, the sensitivity of a group of seven experts was only 12% (SD 6.5%), and the false-positive rate was 7.4% (SD 5.2%) (Kagan et al., 1966). Clearly, the diagnosis of hypertension was made with a stethoscope and a blood pressure cuff. For understanding the vasculopathic effects of the blood pressure in an individual patient, however, an intelligent observation of the fundus has no superior.

Asymmetric hypertensive retinopathy is highly correlated with the presence of significant carotid stenosis (Lawrence and Oderich, 2002).

Diabetic Retinopathy

To summarize, diabetic retinopathy is characterized by microaneurysms, hemorrhages, exudates, and eventually neovascularization. By the time hemorrhages and exudates occur, microaneurysms are generally present; their absence would make one reconsider the etiology of the former signs.

There is an interesting statistical correlation between diabetic retinopathy and Kimmelstiel–Wilson disease. Although not all patients with retinopathy will have Kimmelstiel–Wilson disease, the reverse correlation is so good that if one finds no retinopathy in a diabetic with the nephrotic syndrome, one should search for another etiology for the renal disease.

Diabetic papillopathy was discussed previously. Patients with diabetes should have a thorough ophthalmoscopic examination annually. Patients with hemorrhages, exudates, and (possibly) microaneurysms are candidates for fluororetinography (Diabetic Retinopathy Study Research Group, 1978, 1981). In patients with diabetes, a single cotton wool spot is associated with an increased chance of developing proliferative diabetic retinopathy over the next year and thus is a strong indication for ophthalmologic referral (Diabetic Retinopathy Study Research Group, 1981).

Although some early research suggested that tight regulation of diabetes mellitus is actually accompanied by increased retinopathy, especially cotton wool exudates (Brinchmann-Hansen et al., 1985; Lauritzen et al., 1983), extensive study has shown that progression to proliferative retinopathy is significantly reduced by tight control in both type 1 and type 2 diabetics (Guillausseau et al., 1998; Skyler, 1996; Klein et al., 1996). However, a change from oral agents to insulin in type 2 diabetes is accompanied by a 100% increased risk of retinopathy progression and a threefold increased risk of blindness or visual impairment, emphasizing the need for especially close monitoring when treatment is intensified (Henricsson et al., 1996).

Eyes with neovascularization plus preretinal or vitreous hemorrhage must be treated. Neovascularization alone is an indication for treatment if it occurs on or within 1 disc diameter of the optic disc and exceeds one fourth of the disc in area. Laser photocoagulation can help prevent devastating loss of vision due to diabetic retinopathy.

Risk of Stroke

Retinal microvascular changes due to aging, hypertension, and other processes reflect cerebral microvascular disease. The presence of microaneurysms, hemorrhages, soft exudates (cotton wool spots), hard exudates, macular edema, disc swelling, arteriovenous nicking, and focal or generalized arteriolar narrowing (lowest 20th percentile of the arteriolar-to-venule ratio) was documented by retinal photography in 1,684 persons. Persons with retinopathy were more likely to have cerebral white matter lesions (WMLs) on MRI (22.5% versus 9.9%). Those with WMLs had a higher 5-year incidence of clinical stroke than those without (6.8% vs. 1.4%). Persons with both retinopathy and WMLs had a significant higher 5-year cumulative stroke incidence than those with neither (20.0% vs. 1.4%; adjusted relative risk 18.1, 95% CI = 5.9 – 55.4) (Wong et al., 2002).

The retinopathy seen ipsilateral to occlusive disease of the carotid artery includes (a) cotton wool exudates, (b) yellow plaques of Hollenhorst, and (c) dilation of the arterioles. Additional features recognized in 1963 (Kearns and Hollenhorst, 1963) were called *venous stasis retinopathy*, although they could also be seen in association with carotid artery occlusion. These consisted of (a) microaneurysms in close proximity to the retinal veins, (b) small blossom-shaped (blot) hemorrhages always less than 1/8 disc diameter in size, and (c) dilation of the retinal veins. In the subset of these patients who had an elevation in the erythrocyte sedimentation rate, spontaneous sludging of the blood in the retinal veins was sometimes observed. Except for the absence of waxy (hard) exudates, this retinopathy was felt to mimic diabetic retinopathy exactly.

In a series of patients who underwent cerebral angiography for suspected symptomatic and asymptomatic carotid artery disease, 44% of those evaluated by an ophthalmologist had at least one

of ten findings suggesting carotid disease (Table 10.31). None of these findings had been reported by the admitting house staff or the attending physician. The absence of eye findings does not rule out carotid disease; 53% of the patients without such findings had significant carotid disease (Lawrence and Oderich, 2002).

Self-assessment question: Why did the house staff not make note of the findings of carotid disease? (See Appendix 10.4.)

Sickle Cell Retinopathy

Peripheral retinal capillary occlusion by sickled red cells initiates a proliferative retinopathy, which commonly leads to vitreous hemorrhage and retinal detachments (Talbot et al., 1982). Unfortunately, the results of laser photocoagulation have not been good (Condon and Serjeant, 1980).

AIDS Retinopathy

A retinopathy or microangiopathy related to the human immunodeficiency virus is found in 30% to 60% of infected patients and may precede the occurrence of major AIDS-related infections. Retinal findings are similar to those seen in diabetes mellitus, hypertension, and some vasculitic and rheologic disorders. They include cotton wool spots, "dot and blot" hemorrhages, and microaneurysms. On slitlamp examination, conjunctival vessels may show the irregular caliber, fragmentation, and sludging of blood flow resembling that seen in some patients with sickle cell disease.

Although the microangiopathy tends to be nonprogressive and asymptomatic, it often coexists with findings of viral retinitis. The most common form, occurring in 15% to 40% of patients with AIDS, is due to CMV. This virus invades retinal cells and causes necrosis of all layers of the retina. White patches of retinal edema with hemorrhage have been likened in appearance to "cottage cheese and catsup" (Gariano et al., 1993).

The natural course of CMV retinitis is progression to bilateral blindness. Hence, early diagnosis and treatment is essential. Dr Henry Hudson, III, of Arizona recommends an expert dilated fundus examination with scleral depression every 6 months for any AIDS patient who has ever had a CD4 count less than 100 and every 3 months for a patient who has had a CD4 count less than 50 (Hudson, 1998).

TABLE **10.31** *Ophthalmologic findings in 41 patients who had ocular manifestations of carotid occlusive disease*

Ophthalmologic findings	*n*	Patients with >50% stenosis
Hollenhorst plaque	14	11 (78%)
Retinal artery occlusion		
Central	10	3 (30%)
Branch	1	1 (100%)
Rubeosis iridis	12	10 (83%)
Neovascular glaucoma	6	5 (83%)
Ischemic optic neuropathy	3	2 (66%)
Asymmetric hypertensive retinopathy	2	2 (100%)
Venous stasis retinopathy	2	2 (100%)
Platelet-fibrin plug	1	2 (100%)
Undefined retinal embolus	1	1 (100%)

From Lawrence PF, Oderich GS. Ophthalmologic findings as predictors of carotid artery disease. *Vasc Endovascular Surg.* 2002;36:415–424, with permission.

Retinal Artery Occlusion

If the *central* retinal artery is occluded, the patient will experience a sudden loss of vision, and on examination, the entire retina will appear edematous and pale, except for the cherry-red macula plus any part of the retina that is supplied by the cilioretinal artery that is present in 15% to 20% of people (Fig. 10-20C). Sometimes a hemorrhage may be superimposed. The etiologies are the same as for any arterial occlusion.

Some teach that massage of the eyeball may salvage vision in cases of acute retinal artery occlusion. Movement of the embolus, as observed through the ophthalmoscope, has been reported after this maneuver (De Schweinitz, 1915). If applied soon enough, hyperbaric oxygenation has had a favorable effect on visual outcome by helping to overcome retinal ischemia until recanalization of the artery can occur (Beiran et al., 1993, 2001; Weinberger et al., 2002). A number of other interventions have been tried, including rebreathing carbon dioxide, topical alpha-blockers, anterior chamber paracentesis, antiglaucoma eyedrops, nifedipine, intravenous acetazolamide, glycerol, and hemodilution (Kaye, 1998; Aisenbrey et al., 2000). The time for potential success is probably very short.

Peripheral arteriolar and arterial occlusions are often caused by the plaques of Hollenhorst and the white emboli already described above. The findings will be similar to those described in the last paragraph, except they will be segmental and possibly associated with the characteristic intra-arteriolar findings.

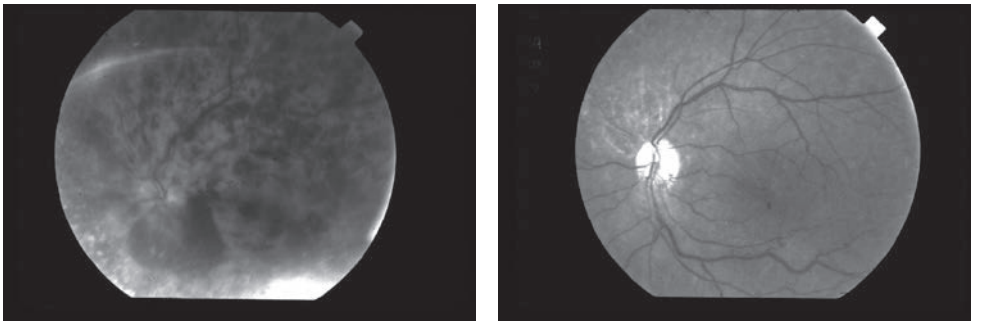
After the acute occlusion and during healing, all or part of the arteriole or artery that was occluded may show arterial sheathing or even silver wiring.

Central or branch retinal artery occlusions are associated with significant carotid artery stenosis (Lawrence and Oderich, 2002).

Retinal Venous Occlusion

In contrast to the usual rather bland appearance of the fundus in a central retinal artery occlusion, a retinal venous occlusion often causes a horrendous appearance of the fundus (see stasis retinopathy, discussed previously in this chapter), with retinal hemorrhages, edema, hard exudates, and retinal infarcts (cotton wool spots). This clinical picture has been described as "pizza fundus" or "blood and thunder" fundus (Fig. 10-35). These changes may occur in all four fundus quadrants (central retinal vein occlusion, or CRVO), the two upper or lower quadrants (hemispheric retinal vein occlusion, or HRVO), a single quadrant (branch retinal vein occlusion, or BRVO), or an even smaller segment.

The most likely cause of CRVO is thrombosis in the central retinal vein, while BRVO is believed to be caused by venous compression at areas of arteriovenous crossings. However, external compression,



A B

FIGURE 10-35 **A:** Fundus photo of the left eye of a 77-year-old woman who had a CRVO for 3.5 months. The extensive retinal hemorrhage and edema caused the typical "pizza fundus" appearance. **B:** Same eye 4 months after REVS with the injection of t-PA into a branch retinal vein. The retinal hemorrhage and edema have cleared, and vision has improved from 20/400 to 20/80.

internal inflammation, internal thrombosis, or any combination of these factors may play roles of varying degrees in CRVO, HRVO, and BRVO. CRVO has occurred after a second dose of hepatitis B vaccine; the first dose had been followed by a prethrombotic state with papillary edema and hemorrhages (Devin et al., 1996).

While visual loss is usually not as acute, severe, or permanent as in retinal arterial occlusion, the visual prognosis in retinal vein occlusion may be very poor, especially in CRVO. Early recognition is important because treatments that target possible mechanisms of retinal venous occlusion may improve the visual prognosis. Retinal endovascular surgery (REVS) involves direct cannulation and injection of the thrombolytic agent tissue plasminogen activator (TPA) into retinal veins to relieve the obstruction in CRVO and HRVO (Fig. 10-35) (Weiss and Bynoe, 2001, 2003). Other treatments include intravitreal steroid injection (Ip and Kumar, 2002), which may address inflammatory mechanisms of vascular occlusion, and arteriovenous sheathotomy and radial optic neurotomy, both of which may address possible compressive problems in BRVO and CRVO, respectively (Opremcak and Bruce, 1999; Opremcak et al., 2001).

Usually, these patients are hypertensive and need excellent blood pressure control to protect the other eye and the brain.

Appendix 10.1

Answers to Questions on Pupillary Light Reflex

In Fig. 10-13, situation A shows a pure right afferent lesion. As both pupils respond when the light is shone into the left eye, both efferents must be intact, as well as the left afferent. Therefore, the absence of any response when the light is shone into the right eye must be due to an isolated right afferent defect. In situation B, the left efferent must be intact because that pupil constricts. Furthermore, as it constricts no matter into which eye the light is shone, both afferents must be intact. Thus, this must be, by logical process of elimination, a pure right efferent lesion.

Appendix 10.2

Answer to Question in Fig. 10-34

The patient had prepared an oral medication for intravenous injection, causing talc embolization (Lee and Sapira, 1973). This picture could also represent AIDS retinopathy, another consideration in a drug user.

Appendix 10.3

Six Pearls of Clinical Ophthalmoscopy for the Primary Care Physician and Medical Consultant

1. Attempting to inspect the fundi through constricted pupils is like eating spaghetti with your fingers.
2. Exudates and hemorrhages are *never* normal.
3. No exudate or hemorrhage is specific (in the diagnostic sense) for any disease, but these findings tell you the vasculopathic and neural effects of the disease in that patient at that particular time better than anything else.
4. Microaneurysms = diabetes mellitus, until proved otherwise.
5. Arteriovenous crossing changes that are complete and more than 2 disc diameters out = chronic moderate hypertension, until proved otherwise.
6. The fact that you do not know its significance does not mean that it does not have significance.

Appendix 10.4

Why Did House Staff Miss the Findings of Carotid Occlusive Disease?

The most likely reason is failure to dilate the pupils. Other reasons: failure to take sufficient time to do a thorough examination and failure to have done enough examinations to recognize that something is abnormal.

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CHAPTER

11

The Ear

Nature, I am persuaded, did not without a purpose frame our ears open, putting thereto no gate at all, nor shutting them up with any manner of inclosures, as she hath done upon the tongue, the eyes, and other such out-jetting parts of the body. The cause as I imagine, is, to the end that every day and every night, and that continually, we may be ready to hear, and by a perpetual hearing apt to learn. For, of all the senses, it is the fittest for the reception of the knowledge of arts, sciences, and disciplines.

—Rabelais, *Gargantua and Pantagruel*, III, 16

Points to Remember:

- Abnormalities of the external ear occur in many congenital conditions, especially renal abnormalities.
- Note the position and shape of the pinna and examine the skin and the cartilage. Pay attention to the ear canal as well as to the tympanic membrane, including its entire periphery.
- If you fail to screen for hearing impairment, you will miss a lot of important pathology. Never assume that you can rule out hearing loss by the "grossly intact" test.

External Inspection

It is best to examine the patient, with him sitting up, if possible, so that his ears are approximately at your eye level.

Deformities of the External Ear

Low-set ears have been referred to for decades as a sign of Down syndrome and other congenital anomalies (Fig. 11-1). Ears appear to be low set if the neck is short or extended, if the cranial vault is high, if the ramus of the mandible is short, or if the auricles are rotated. One definition of low-set ears is that they are completely beneath a coronal plane passing through the pupils and palpebral fissures. In neonates, this definition produces false positives. Measurements of the distance between the upper and lower attachments of the auricles and a bony landmark on the zygomatic process showed a wide variation in 1,000 apparently normal newborns (Oommen, 1997).

Deformities of the ear, including those of just the earlobe, are said to correlate with renal abnormalities, predicting the side(s) of the lesion. To demonstrate this, one needs a patient from whom an intravenous pyelogram has been obtained. As this is not a routine screening test, this clinical correlation is at least partly based on a biased sample, leading to an artifactually increased predictive value of a positive test. (In other words, no intravenous pyelogram would have been performed unless there had been some reason to suspect a renal problem.) Still, the correlation seems to be a useful one, although many of the anomalies are benign and asymptomatic, such as reduplication of the ureter on the side of the ear malformation.

Swelling of the skin of the anterior or external surface of the pinna with or without tenderness is a sign of subcutaneous hematoma or abscess. This is usually due to blunt trauma or traumatic twisting or bending of the pinna. Without immediate surgical intervention, the result would be "cauliflower ear," which is caused by the dissolution of the cartilage and the formation of scar tissue. This abnormality was typical of people engaged in the sport of wrestling before protective head gear was used.

Earlobe Creases

Earlobe creases (also called *Frank creases* for their discoverer) are a risk factor[1] for coronary artery disease (Elliott, 1983; Frank, 1973) (Fig. 11-2). As they may occur on only one side, be sure to look at both earlobes.

A study of 340 consecutive patients undergoing coronary arteriography has shown that the Frank sign, if present in either ear and extending for a distance greater than half the diagonal length of the earlobe, correlated with coronary artery disease, age, and arcus senilis (Pasternac and Sami, 1982). The sensitivity of the sign was 60%. (Review Chapter 1 and write down definitions for sensitivity, specificity, and positive predictive value on a piece of paper.) The specificity of the test was 82%. (Recall that specificity refers to the chance that a person who does not have the disease will not have the sign.) The positive predictive value of the sign was 91%. This suggests that the test is a fairly reliable one.

Dr A.I. Mendeloff of Maryland points out that 75% of the subjects (in this study) had coronary artery disease. That is, the study population had a very high prevalence of the disease in question, much higher than the prevalence that would be seen in a supposedly random population presenting at *a* physician's office. As the prevalence of the disease would actually be much less in a nonselected population, would you expect a study of the Frank earlobe crease using the same criteria but a randomly selected population to produce a different result for sensitivity, specificity, or positive predictive value? Write down your answers at this point. (*Hint*: Ask yourself which items in the equations would be increased by diluting the numbers in the present study with persons who have no coronary artery disease.)

In a review of the world literature (Elliott, 1983) involving 6,414 cases with varying criteria for the diagnosis of coronary artery disease, 1,721 cases had a true-positive earlobe crease, 1,034

[1] Remember, a risk factor is a statistical phenomenon. A risk factor is not necessarily an etiologic factor.

Figure 11-1 Noonan syndrome. Low-set ears, a nose with a broad bridge, a short neck, and pectus excavatum are also seen in this patient. (From Gellis SS, Feingold M. *Atlas of Mental Retardation Syndromes: Visual Diagnosis of Fades and Physical Findings*. Washington, DC: U.S. Department of Health, Education, and Welfare; 1968, with permission.)

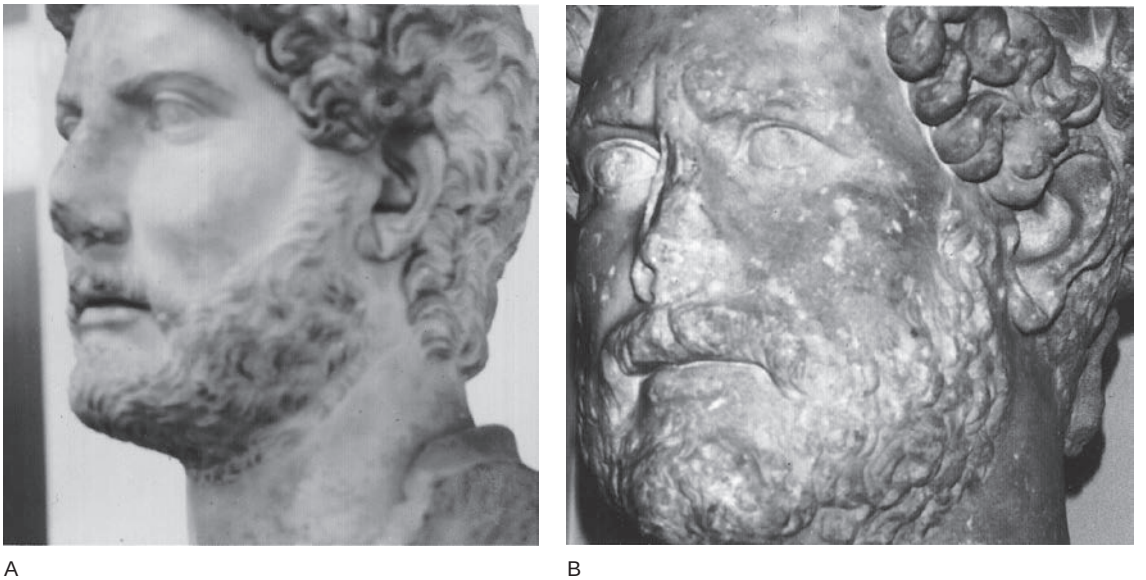
had a false positive, 1,112 had a false negative, and 2,547 had a true negative. In Elliott's 1,000 consecutive personal cases, including 843 general medical admissions and 157 patients from a cardiac catheterization lab, there were 275 true positives, 98 false positives, 101 false negatives, and 526 true negatives (Elliott, 1983).

Exercise for the Student. Construct 2 × 2 contingency tables and calculate the sensitivities, specificities, and positive predictive values for the literature review and for Elliott's series. What are the predictive values of a negative test? (The answer is in Appendix 11.1.)

Age is a confounding variable. The degeneration of the elastic substance around arterioles, which is thought to be the cause of the crease, is an accompaniment to arteriolar sclerosis and also occurs with aging. However, the association with coronary artery disease exists in all age groups (Elliott, 1983).

A smaller subsequent study failed to find a significant association between earlobe creases and coronary artery disease (Brady et al., 1987). In analyzing such papers, students should ask the following questions: (a) What is the power of the study? Were sufficient patients included to have a reasonable chance of finding an association, if it exists? (b) Were confounding variables, such as hypertension, age, and smoking, handled appropriately (as by a multivariate analysis)? (c) Was there a selection bias? If the risk factor is associated with a disease at a young age, a noncohort study of an elderly population may be negative because of premature "die-out" of affected individuals (this may also account for negative results in some of the later studies of type A personalities), and (d) Is there publication bias? (That is, doctors who believe in modifying risk factors might not be interested in findings that do not suggest a compensable intervention.)

A 10-year follow-up of 264 consecutive patients from a university-based coronary care unit and cardiac catheterization laboratory showed that the number of creased ears was significantly associated with a higher rate of cardiac events. The 10-year cardiac-event–free survival was 43.5% ± 5.7%, 33.0% ± 6.7%, or 17.5% ± 4.6%, $p = 0.0003$, respectively, for zero, one, or two earlobe creases (Elliott and Powell, 1996). These authors noted that earlobe creases were a more important predictor of future cardiac events than diabetes, hypertension, cigarette use, hypercholesterolemia, family history of coronary disease, or obesity.



A B

Figure 11-2 Diagonal earlobe creases in the busts of Hadrian in the Museo Nazionale Romano **(A)** and in the Athens National Museum no. 3729 **(B)**. (From the masterful essay on the diagonal earlobe crease, type A behavior, and the death of Emperor Hadrian [Petrakis NL. Diagonal earlobe creases, type A behavior, and the death of Emperor Hadrian. *West J Med.* 1980;132:878–891], with permission.)

Skin Lesions

The external ear may be affected by skin lesions, including solar keratoses and carcinomas, both basal cell and squamous cell. The skin of the pinna and external canal is frequently involved in seborrheic dermatitis and other dermatoses, which cause scaling, edema, and inflammation. A vesicular rash on the pinna occurs in Ramsay Hunt syndrome, caused by a herpes zoster infection of the facial nerve; it should be specifically sought in patients presenting with a facial paralysis (see Chapter 26).

Other Findings

Collections of urate in the form of tophi may be seen in the external ear, but these are quite rare these days owing to the combination of automated uric acid analyses and effective hypouricemic drugs. Nevertheless, if found in an arthritic patient, they could be a valuable clue to a gouty etiology.

See Chapter 17 for the winking earlobe signs.

Protrusion or proptosis of the auricle is reported in 42% of patients with acute mastoiditis, an abnormal-appearing (such as a sagging or narrowed) external auditory canal in 80%, and otorrhea in 26%. The reason for the first two findings is cortical dehiscence of the bone. A history of antecedent otitis media is present in only 45% of patients, although most (88%) have an abnormal-appearing tympanic membrane. Postauricular tenderness and edema (see Chapter 9) are frequently seen. Although the incidence of mastoiditis declined dramatically with the introduction of antibiotics, it still occurs and can cause serious complications. Pain is the presenting symptom in almost all cases (Gliklich et al., 1996).

Palpation

Feel the external ear and tug on it. Is it painful? Pain when pressing the pinna between the thumb and index finger can be found in early cases of chondritis, even before swelling develops. If the pinna itself is not tender but movement causes great pain, the patient will almost always have otitis externa. This will usually be accompanied by swelling of the skin of the external auditory canal, but this finding may be absent in early stages. Otitis media by itself does not produce tenderness with movement of the pinna. Also, check the mastoid process for tenderness (see Chapter 9).

Floppy ears may be seen in relapsing polychondritis. However, not all patients with this disease actually have floppy ears; sometimes the ears simply show inflammation of the pinna. In one series collected in a single institution, 85% of 112 patients with relapsing polychondritis had some evidence of such auricular chondritis at some point during their illness (Michet et al., 1986).

A Note to Sophomores. You have probably not heard of the disease relapsing polychondritis. Thus, it is a "border phrase": a phrase on the border of this work and another, a textbook of medicine. This is a good time to apply the technique suggested in Chapter 6 for increasing your apparent IQ. Jot down this unfamiliar term and look it up before you go to sleep tonight.

Dr Mendeloff of Maryland, who has seen many patients with Addison disease, notes that stiffening of the earlobe is a useful sign favoring that diagnosis. This phenomenon is distinct from the addisonian calcification of cartilage, which is nondiagnostic, having also been reported in other endocrine disorders such as hyperthyroidism, pseudopseudohypoparathyroidism, diabetes mellitus, acromegaly, and hypopituitarism and in metabolic disturbances including ochronosis and hypercalcemia. In the two cases of acromegaly that had such calcification, pituitary and adrenal insufficiency were not excluded. It has also been seen in sarcoid, presumably because of hypercalcemia. Furthermore, it may occur in conditions that produce localized injury to tissue, such as frostbite, trauma, and inflammation (bacterial chondritis, nonbacterial chondritis, and perichondritis). Miscellaneous etiologies are senile keratosis and idiopathic calcification in the aged (Randall and Spong, 1963).

Internal Inspection

A Method

1. From your collection of specula, select one that is the correct size for the patient. Use the largest one possible that gives the best view and that provides the least chance of hurting the patient. Disposable specula are preferable. If these are not available, check that the speculum was cleaned (by washing in hot soapy water and rinsing with alcohol) since its last use.
2. Turn the light on. For examining the patient's right ear, place the otoscope in your right hand so that your left hand is free to lift the patient's external ear superiorly, posteriorly, and away from the head to straighten the ear canal of adults and older children. (In infants, you will need to pull inferiorly on the auricle.)

   For the left ear, some physicians hold the otoscope in their left hand so that they can manipulate the ear with their right hand without having to cross hands. Others hold the otoscope in their dominant hand for both ears.
3. Hold the otoscope so that you are comfortable. Most people grasp it like a hammer. Others cradle the battery compartment in the "V" between the thumb and forefinger with the handle pointing up. The latter has the advantage that for an uncooperative patient or excitable child, you can rest the ulnar edge of your hand against the patient's head so that you will automatically move the otoscope if the patient moves his head and so avoid injuring the ear canal. Examining such a patient in the lateral decubitus position will also reduce the potential movement of the head.
4. Look through the otoscope. Insert the speculum in the canal, as you tug on the ear with your other hand (see step 2 above). (If you are performing this examination correctly, it should be nearly painless, unless the patient has a furuncle or foreign body in his ear canal.)
5. If there is cerumen in the canal, clean it out with warm mineral or olive oil and a cotton-tipped swab. Do not use a swab to remove hardened wax as you may impact it against the eardrum.

You may be able to lavage wax from the canal with water and an ear syringe (after softening it with over-the-counter drops such as Debrox or baby oil). Do not lavage the canal if a perforated eardrum is suspected. In any case, be sure to use water of approximately body temperature; cold or hot fluids will set up thermal currents in the endolymph, induce nystagmus, and induce vomiting in some patients (see "Caloric Testing," Chapter 26).

If you use a blunt cerumen spoon to remove wax, do it only under direct vision, preferably using a head mirror (a skill accrued only with considerable practice, usually from working in the ear, nose, and throat [ENT] clinic). It is also possible to remove the lens from most otoscopes so that you can place the cerumen spoon through the speculum. This author finds it easiest to have an assistant pull on the patient's ear to straighten the canal while she illuminates the canal with the otoscope held in her left hand, near but not in the canal, and removes the cerumen with an instrument held in her right hand.

If you have access to a suction apparatus and no. 8 and 12 suction tubes, along with a no. 14 ear suction tube, vacuum removal of cerumen is the least traumatic technique. One touches only the cerumen with the suction tube and not the skin of the external canal or the tympanic membrane. Dr Vernon L. Goltry of Boise, Idaho, reports that in more than 30 years of experience, patients have uniformly approved of this technique over all others. It is important, especially with children, to reassure them not to be startled by the sound of the suction.

In truth, many physicians simply do not clean out the canal if it is occluded with cerumen. Sometimes one can get a partial look at the eardrum. If the Weber and Rinne tests (*vide infra*) are normal and the patient has no complaints referable to the ear, examination of the eardrum is less critical. Otherwise, you must visualize the eardrum.

Reminder: Do not forget to clean (or discard) the speculum on your otoscope before putting it away.

Ear Canal

Inspect the external canal for foreign bodies, such as errant insects, pebbles, sponges, or pieces of food (in the toddler age group). Blood in the external canal can be a useful sign of temporal bone fracture in cases of acute head injury but is more often due to self-inflicted trauma or furuncle rupture. It may also be seen in myringitis bullosa when surface vesicle rupture occurs with sudden disappearance of severe pain.

An exquisitely tender red spot is a furuncle, even if it does not have a white center.

In external otitis, the canal may be edematous, inflamed, and coated with an exudate. It may be difficult to distinguish infectious from noninfectious etiologies. "Swimmer's ear" due to a variety of bacteria, but especially *Pseudomonas*, is a common external otitis. It is often accompanied by severe pain and tenderness over the tragus, especially on moving the pinna. Tender regional adenopathy may be present. In fungal infections, tiny fungus particles may be seen in the canal with thick exudate. Fungal parts may be white, gray, black, tan, yellow, or blue-green in color.

External otitis in elderly diabetics is of very serious concern as it may progress to malignant external otitis and osteomyelitis of the temporal bone.

A bony exostosis in the canal is a rounded nodule of hypertrophic bone, frequently seen in persons who swim in cold water. It is nontender and hard. Unless it completely occludes the canal, it is an interesting but harmless finding.

It is to be distinguished from an osteoma, a benign tumor that is attached to the inner third of the canal wall by a bony pedicle.

Tympanic Membrane

Look for the landmarks on the tympanic membrane. Figure 11-3 is a highly schematic diagram. The shadows are seldom seen; it is quite rare to see all three of them in the same patient. Similarly, the flaccid part is usually not so well visualized as the diagram suggests.

Manubrium is the Latin word for handle. The umbo was the protuberance in the middle of a Roman shield; the umbo of the *malleus* (hammer) is a similar protuberance. *Annulus* means rim or ring. If the tympanic membrane is retracted, as with blockages of the eustachian tube, the umbo will stand out greatly. If the membrane is bulging outward and inflamed and the landmarks are obscured, the diagnosis of acute suppurative otitis media can be made. If bubbles are seen *behind* the eardrum, one may diagnose acute serous otitis media. There may also be a fluid level behind the drum. If the fluid is high enough to reach the manubrium of the malleus, this line, which is actually a meniscus, may break in two and appear as two slightly curved lines (menisci) bowed out from the manubrium. Sometimes both the meniscus and the bubbles may be seen.

Blisters, looking like bubbles on the near surface of the drum, are bullae or vesicles. Myringitis bullosa is not diagnostic of mycoplasma infection as it is also seen with bacterial infections or even viral infections as in the Ramsay Hunt syndrome.

Blood behind the tympanic membrane (or hemotympanum) is seen in fractures of the skull. The sign was discovered by the British surgeon W.H. Battle (1855–1936), who also described several other signs of similar significance (see Chapter 9).

Cholesteatomas

The annulus must be carefully inspected over its entire circumference because perforations involving the annulus can lead to cholesteatomas. A cholesteatoma, which may originate from the flaccid part (in primary acquired cholesteatoma) or the tensa part (in secondary acquired cholesteatoma) of the tympanic membrane, is a cystic structure lined with squamous epithelium. Congenital cholesteatomas can develop behind an intact eardrum. Contrary to its name (a misnomer), a cholesteatoma does not contain fat.

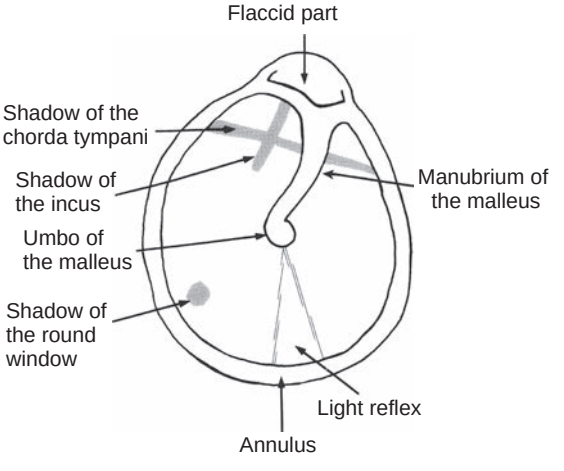


FIGURE 11-3 The tympanic membrane of a right ear.

A cholesteatoma seems to take on a life of its own, penetrating through the tympanic membrane and sometimes even eroding bone in the mastoid or middle ear through the effects of pressure and enzymatic activity. This effect is best demonstrated by a computerized tomography scan.

A cholesteatoma may appear as a little pearly or fatty fleck, as if a bit of Brie had stuck to the annulus. It might be seen as a silvery ovoid behind an intact eardrum (V.L. Goltry, *personal communication*, 1998). The only finding on physical examination might be an ear canal filled with mucopus and granulation tissue.

The presence of a cholesteatoma should be suspected when mastoiditis occurs in an older child (Harley et al., 1997). Check for cholesteatoma in patients with facial nerve paralysis; in the pre-antibiotic era, 2.3% of patients with chronic otitis media had this complication. Cholesteatoma is the main cause of most of the complications of chronic otitis media, which include labyrinthitis, hearing loss, meningitis, extradural or brain abscess, and lateral sinus thrombophlebitis (Nissen and Bui, 1996).

Central perforations not involving the annulus are usually due to trauma or severe bouts of otitis media and seldom, if ever, lead to cholesteatoma.

Eardrum Mobility

The mobility of the eardrum can be observed through a pneumatic otoscope. This device allows one to change the air pressure in the external auditory canal after a seal has been obtained. Use the minimum amount of pressure. Bulb attachments may be able to exert pressures of 1,000 mm H_2O or more, while only 10 to 15 mm H_2O is needed to assess eardrum mobility (Rothman et al., 2003).

Alternately, you can ask the patient to hold his nose and swallow. Sometimes you can see eardrum motion in this way (without the fancy equipment).

An immobile eardrum may result from a perforation, old middle ear adhesions, a blocked eustachian tube, a middle ear effusion, or acute otitis media (presumably due to a combination of edema, inflammation, and fluid).

Distinctly impaired mobility is one of the best signs of acute otitis media, with an adjusted positive likelihood ratio (LR) of 31 (95% CI = 36 to 73). Normal mobility has an adjusted negative LR for acute otitis media of 0.2 (0.19 to 0.21). The only better signs are bulging of the eardrum, with an adjusted positive LR of 51 (36 to 73), and a cloudy appearance of the eardrum, with an adjusted positive LR of 34 (28 to 42). The normal position and color of the eardrum have adjusted negative LRs of 0.4 and 0.1, respectively. A distinctly red color of the eardrum has an adjusted positive LR of 8.4 (6.7 to 11), with the likelihood increasing with the intensity of the redness (Rothman et al., 2003).

It is especially important to perform pneumatoscopy in children (but practice on adults first!) because decreased eardrum mobility can result in impairment of hearing and language acquisition when it occurs during a critical stage of development. Screening for hearing loss in children is beyond the scope of this text, but its importance is shown by the fact that a child with no hearing impairment will commonly have a vocabulary between 5,000 and 26,000 words by the age of 5, whereas a deaf child will have a vocabulary of only 200 signed or spoken words (Crouch, 1997). Deaf children typically graduate from high school unable to read a newspaper (Davis, 1997). They are unable to grasp the great secret of the universe, expounded by Rudyard Kipling in the *Just So Stories*, that *letters stand for sounds*. (Students with normal hearing may also be ignorant of that secret as a result of the modern educational pogrom against phonics.)

A Complication of Otitis Media

For the Advanced Student. The triad of otitis media, paralysis of the lateral rectus muscle, and pain in the orbital or retro-orbital area, described by Gradenigo in 1907, results from spread of infection to the petrous apex (also see Chapter 9). The pain is caused by irritation of the ophthalmic branch of the fifth cranial nerve (Block et al., 1996).

Nonotologic Causes of Otalgia

When a patient complains of ear pain and outer or middle ear disease is not present, a source of referred pain elsewhere in the head and neck must be considered. Trauma, inflammation, or a tumor of a structure along the course of cranial nerves V, VII, IX, and X or cervical nerves C2 or C3 may cause pain referred to the ear.

The most common cause, in Dr Goltry's experience, is dental. There may be a problem with the third molar, especially in a healthy adolescent, or a dental abscess in the posterior mandible or maxillary molars. Common explanations for nonotologic ear pain seen by otolaryngologists also include bruxism (grinding of the teeth as a manifestation of emotional distress, especially while sleeping) or malocclusion due to missing teeth, a poorly fitting crown, a filling that is too high, or poorly fitting or worn-out dentures.

Typically, such patients complain of ear fullness; sharp shooting ear pains (due to muscle spasms of temporalis, masseter, or pterygoid muscle groups); dull, deep ear pain; or any or all of these. They have frequently been treated with antibiotics to no avail. They may complain of a hearing loss that is not confirmed on proper testing.

Physical findings include tenderness of the mandibular head, the posterior ramus of the mandible, the posterior belly of the digastric muscle, the temporalis, or the masseter. Salivary gland pathology or carcinomas of the upper aerodigestive tract, especially the pyriform sinus, are other possible causes, which are of particular concern in smokers and heavy alcohol drinkers.

Auscultation

Listening to the skull is described in Chapter 9. If the patient complains of tinnitus (a noise in the ear or sometimes in the middle of the head), the physician should listen; he may be able to hear the sound that is bothering the patient if it is of vascular origin.

If the patient complains of a whooshing sound, he may be hearing the noise of an arteriovenous fistula anywhere from the carotid up into the temporal lobe. Alternately, he may be describing the vascular tinnitus that afflicts the elderly and that is not pathophysiologically based on arteriovenous fistula but rather on a vascular stenosis with a high-grade obstruction maintained throughout systole and sometimes part or all of diastole.

In the latter case, the physician usually cannot hear the sound but might still be able to make the diagnosis by temporarily occluding the carotid artery ipsilateral to the ear in which the patient reports the sound. That will stop the blood flow and therefore stop the tinnitus (see precautions, Chapter 9).

A continuous sound, like water running, that the patient can hear but the doctor cannot, may be due to a ventriculoperitoneal shunt. To make the diagnosis, damp the shunt for a time. The sound should immediately disappear, only to recur when the occlusion is released (Ordia et al., 1987).

A consultant was once asked to examine a patient in whom the sound of a ticking watch could be heard emanating from the left ear. On auscultation of the left preauricular area, a clicking sound was heard, which would begin and stop abruptly. (The sound could actually be heard without a stethoscope.) The sound stopped when the patient held his breath. The consultant diagnosed cyclic obstruction of the left eustachian tube because he could think of nothing else.

Question: What might have been done to refute the consultant's misdiagnosis? (Appendix 11.2)

The symptoms of the "Bulova watch syndrome" were probably due to myoclonus of the tensor veli palatini muscle, which is located in the soft palate and serves to open and close the eustachian tube. The contractions can be seen by looking in the patient's mouth. This condition is rare; a consultant may see a case once in 30 years. Myoclonus of the tensor tympani, a protective middle ear muscle attached to the malleus, can also produce a fluttering of the eardrum in certain individuals. Both of these ticlike syndromes usually disappear with time (J. Boyles, *personal communication*, 1998).

Tinnitus That the Doctor Cannot Hear

Tinnitus may be caused by disorders in any part of the hearing mechanism, including the external auditory canal, middle ear (as from otitis media or vascular tumors), the inner ear (cochlea), the eighth cranial nerve, or the central auditory pathways and centers. When constant and accompanied by an auditory defect, it is more likely to be of cochlear or central origin; hearing should always be checked. When intermittent, tinnitus is more likely to be caused by Ménière disease or an allergic disorder.

Nonotologic causes of tinnitus were discussed in detail in Chapter 3.

Methods of quantitating tinnitus are described later in this chapter.

Special Maneuvers

Testing for a Blocked Eustachian Tube

If the eustachian tube is obstructed, the examiner should in most cases be able to see fluid behind the eardrum, with or without a pneumatic otoscope. Tell the patient to perform the Valsalva maneuver by saying: "Hold your nose and your mouth tightly shut and breathe out very hard." This forces air into the middle ear space, relieving the fullness and allowing the examiner to see bubbles behind the eardrum. Tuning fork tests (*vide infra*) should show signs of a conductive hearing loss.

Autophonia may be due to a eustachian tube syndrome. The patient complains that he can hear himself breathe and that his own voice is too loud, whereas other noises are normal. The eardrum appears normal. To confirm the diagnosis, have the patient lie down. In the recumbent position, the palate is relaxed, the eustachian tube will close, and the patient's symptoms will immediately disappear.

Checking for Hearing Loss

Those who believe they can detect hearing defects by simply observing a patient's behavior are usually wrong.

For example, who would have thought that a totally deaf person could compose the score illustrated in Figure 11-4?

Self-assessment questionnaires have been developed, such as the Hearing Handicap Inventory for the Elderly-Screening (HHIE-S), but it is important to remember that such tests screen for functional impairment, not physiologic hearing loss (Yueh et al., 2003). Thus, they cannot substitute for actual examination of the patient.

Walk *behind* the patient and whisper an instruction such as, "Raise your right arm." If the patient responds appropriately, he has passed a very crude screening test for total or severe *bilateral* hearing loss.

Alternately, ask him in a natural voice to repeat "the following numbers" and then whisper a random set of numbers, such as your unlisted telephone number. To test the ears *separately*, you must have him occlude first one ear, then the other.

To distinguish a conduction from a sensorineural hearing loss, you *must* perform the Rinne and Weber or Schwabach tests (*vide infra*).

FIGURE 11-4 What totally deaf person composed this? (See Appendix 11.3.)

Often, persons who will not take a few seconds to do a Weber and a Rinne test cannot think of anything more original to whisper than "1, 2, 3,…" and thus the patient can transfer the "sound" information from the good ear to a good guess on the bad side, or if the numbers are whispered in front of the patient, he may be able to read the examiner's lips. If you stand in front of the patient and hold your wristwatch near his ear, he may respond affirmatively to your query about ticking—even if he is deaf and even if you have a digital watch.

I personally perform the Weber and Rinne tests as my screening tests on all comers.

The Weber Test

If one ear is occluded and one ear is open, the tone will be stronger in the occluded ear than in the open ear.

—E. H. Weber, *De Pulsu Resorptione, Auditu et Tactu*, 1834 (from a discussion about a tuning fork, which, while vibrating, had been applied to the teeth.)

Self-study

Normally, vibrations are transmitted through solid matter quite well. Strike your tuning fork (preferably 1,024 or 512 Hz) and hold the base against your skull in the midline. You may hold the fork against the top of your skull or your forehead or the front incisors; the important factor is that the fork be equidistant from your ears. Note that the sound is heard in both ears. Obviously, if you had sufficient neural damage on one side, you would not hear the hum on that side. The Weber test would then be said to have lateralized to the good side.

What makes the Weber test so valuable is that in cases of conduction deafness (e.g., middle ear disease), which spares the neural tissue, the Weber lateralizes to the bad side! To demonstrate this, give yourself a temporary left conduction loss (sparing neural tissue) by occluding your left external canal with a finger. Now place the vibrating fork against your skull in the midline, note that the sound is louder on the left side, where the canal is occluded. If you cannot appreciate this, rapidly occlude and unocclude the external canal on that side (about once per second) as the midline tuning fork vibrates.

A Method

1. Place the vibrating tuning fork on the patient's skull on the midline.
2. Ask, "What do you feel?" The patient may say, "buzzing," "tingling," or some phrase that refers to vibration. Note that the feeling of vibration has nothing to do with the Weber test per se but gives the patient a reference point for later testing of vibratory sensation. Without such a reference point, patients may feel the pressure of the tuning fork and say, "Yes, I feel it" (with reference to the tactile sensation) even though they cannot perceive the vibrations. (Although vibratory testing [see Chapter 26] is part of the neurologic examination, in practice, you should do it at this point while you have the tuning fork in hand. The rest of the method described here, however, is concerned only with hearing.)
3. As the fork continues to vibrate, ask the patient, "Do you *hear* anything?" If he says, "No," have him close his eyes and question him again. (If he really cannot hear the fork in either ear, then he cannot have a conduction defect and must have a complete bilateral neural defect. In that case, however, how could he hear your second question with his eyes closed? Keep trying.)
4. When he says, "Yes," ask him, "Which ear?" Most patients with normal hearing will say, "Both." A normal Weber test is recorded as "midline." A lateralizing Weber test is recorded as the side on which it is heard (e.g., "lateralized to the left") (see Chapter 4).

Some overly cooperative patients with normal hearing will attempt to please you by picking one side. In that case, you may have to "help" the patient by repositioning the fork, repeating the test, and saying, "Can you hear it in both ears now?" However, you should not say this initially as it is a form of "leading the witness." In any event, such false lateralizations might give some information about the patient's personality, if not his ears. Of course, one can only know if this is a false lateralization by checking whether the results are consistent with the Rinne test and the other parts of the examination.

The Rinne Test

Self-study

Convince yourself of the fact that normally air conduction is better than bone conduction. Strike the tuning fork and place the base over your right mastoid prominence. Listen to the sound fade. The moment it disappears, quickly move the fork from the mastoid and place the vibrating tines as close to the right external canal as possible without damping them on your hair or auricle (you may need to use a mirror and/or your free hand to hold your hair back from the ear). The sound will reappear. Repeat the test on the left side. Now try the Rinne test on your partner, using the instructions given below.

A Method

1. Place the vibrating fork on one of the patient's mastoid prominences. Ask, "Do you hear anything?" (If the patient does not hear anything, you have identified severe to total sensorineural hearing loss on that side and should proceed to the other side.)
2. When the patient answers, "Yes," say, "Tell me the very instant it goes away."
3. When he says that it is gone, immediately move the fork from the mastoid and place the vibrating tines as close as possible to the ipsilateral external canal. If the patient does not spontaneously volunteer something like "It came back" or "I hear it," ask, "Now?" Normally, he will nod "yes" or say words to the effect that he can again hear the sound.

A normal Rinne test would be recorded as follows: AC (air conduction) > BC (bone conduction) bilaterally (see Chapter 4).

Patients with conduction defects will not hear the sound return because for them bone conduction is greater than air conduction. On the other hand, with sensorineural impairment, the Rinne test remains normal: both air conduction and bone conduction are decreased, but the relative superiority of air conduction remains.

When you test a patient with unilateral sensorineural loss, you will note that the examination is performed very quickly on the bad side, that is, the sound fades much more rapidly than on the normal side. Accordingly, some investigators have suggested quantitating the difference by counting the number of seconds required for bone

conduction to decay on the two sides. This presumes that you are able to strike the tuning fork with the same impetus every time you perform the test. Another modification for picking up bilateral partial sensorineural loss in a patient who has normal Rinne and Weber tests is to see whether you can still hear the vibrating fork when the patient reports that air conduction has ceased. This presumes that the examiner has normal hearing.

False Positives

Some overly cooperative patients may wait to "be sure" that the sound has disappeared from the mastoid and so delay reporting its cessation for so long that almost all fork vibrations have ceased before they say, "It's gone." For them, you may need to repeat the test, strongly emphasizing the words "the very instant it's gone" in the instructions.

Historic Note

Some examiners ask the patient to listen to a watch ticking. Perhaps this is in tribute to Sir Astley Cooper (1768–1848), who anticipated the Rinne test by performing it with a pocket watch rather than a tuning fork. For this, he won the Copley medal, although he is better remembered as the first surgeon to ligate an abdominal aneurysm (Morton, 1983). Others will remember him as being the attending physician for the medical student John Keats (Laborde, 1986).

Synthesizing the Results

Remember to check both the Weber and Rinne tests for each ear. This will enable you to determine whether there is a hearing loss, whether it is unilateral or bilateral, and whether it involves a conduction or sensorineural defect (Table 11.1). For example, what would cause the following: Weber lateralizes to the left, AC > BC R, BC > AC L?

(The most common cause of a lateralizing conduction defect is the occlusion of the external canal by cerumen. That is why you should do the Weber and Rinne tests after carrying out the inspection of the ear.)

It is quite amazing how many patients who are described as "peculiar" or who have a vague psychiatric "diagnosis" (Fig. 11-4 and Appendix 11.3) turn out to have hearing loss when examined according to the above scheme. Many of these have been reported as having normal hearing by whispering alone, wristwatch alone, or the ubiquitous "grossly intact" test.

A Case Report

Dr Goltry of Boise recently treated a remarkably healthy 90-year-old man who carried a diagnosis of "dead ear." Apparently, no one had bothered to perform a Rinne test, which revealed a conductive hearing loss. The patient was unable to benefit from a hearing aid because it was unable to overcome the conductive loss. The diagnosis of otosclerosis was made, and a stapedectomy was performed with insertion of a prosthesis. An effective hearing aid then restored the patient's binaural hearing, which permits triangulation and sound localization.

In this case, simple technology (a 512-Hz tuning fork) and the art of medicine led to a treatable diagnosis that had been missed in this era of overreliance on laboratory tests and ofttimes prohibitively expensive technology (V.L. Goltry, *personal communication*, 2004).

The Schwabach Test

The Schwabach test compares the patient's bone conduction with that of the examiner's (who has normal hearing). As with the Rinne test, the vibrating tuning fork is placed against the mastoid, and the patient is asked to report when the vibrations cease. Immediately, the examiner places the tuning fork against his own mastoid and records the time (in seconds) until the sound ceases. If he cannot hear the sound, the order of the examination is reversed. The examiner listens until the sound ceases and then places the tuning fork against the patient's mastoid.

The Schwabach test is normal when patient and examiner have approximately equal conduction times. The Schwabach test is said to be diminished when the examiner can hear the tone long after the patient. That is a sign of sensorineural impairment. The Schwabach test is said to be increased or prolonged when the patient's bone conduction is appreciably longer than the examiner's. This occurs in conductive hearing loss because the room noise masks the sound of the tuning fork in a normal ear but not in the one with a conduction defect. Thus, this test is the only examination that should not be conducted in a perfectly quiet room!

For additional methods to check hearing, see Chapter 26.

TABLE **11.1** *Diagnosis of hearing loss*

Diagnosis	Weber test	Rinne test		Schwabach test	
		Right	Left	Right	Left
Normal	Midline	AC > BC, about 60 s	AC > BC, about 60 s	N	N
Right conduction loss	→ R	BC > AC	AC > BC	P	N
Partial right sensorineural loss	→ L	AC > BC, about 10 s	AC > BC, about 60 s	D	N
Total right sensorineural loss	→ L	Cannot hear at all (BC, 0 s)	AC > BC	Cannot hear	N
Bilateral conduction loss	Midline	BC > AC	BC > AC	Not done	

AC, air conduction; BC, bone conduction; N, normal; P, prolonged; D, diminished.

Explicating a Paradoxical Rinne Test

For the Very Advanced Student. Some patients who are overly cooperative and/or cerebrally insufficient may give a paradoxical Rinne test (i.e., bone conduction greater than air conduction on the side of a unilateral total sensorineural defect). Such patients have "learned" to perceive the vibration of the fork against the skull on the defective side, coupled with the experience of hearing the bone conduction in the opposite ear, as "hearing." The Schwabach test should clarify the situation. However, in the event that your own hearing is impaired and you cannot do a Schwabach test, you might try the following maneuver.

Repeat the Weber test (which lateralizes to the healthy side), slowly marching the tuning fork from the midline toward the mastoid on the affected side. The patient will continue to lateralize the Weber correctly back to the intact side. However, sometimes you will reach a zone of demarcation close to the afflicted ear where the patient begins to "lateralize" to the afflicted side. If you then occlude the good ear, the "line of demarcation" for the Weber test will not move at all because the "cooperating" patient is still responding to the learned skull sensation of the tuning fork and not to the sound.

In contrast, a patient who is responding to sound will hear better in the occluded ear, and the zone of demarcation will shift.

On Sudden Hearing Loss

Sudden hearing loss may be reversible, if recognized and treated promptly, by discontinuing ototoxic drugs. These include antibiotics (aminoglycosides, erythromycin, and vancomycin), antineoplastics (cisplatin, carboplatin, and vincristine sulfate), loop diuretics (furosemide and ethacrynic acid), and antiinflammatories (aspirin and quinine). When known ototoxic drugs need to be administered, it may be desirable to screen patients for early signs of high-frequency hearing loss (Yueh et al., 2003). High doses of hydrocodone/acetaminophen combinations have also been associated with profound hearing loss (Friedman et al., 2000; Oh et al., 2000).

Noise exposure can cause hearing loss and accelerate presbyacusis. Even short blasts of loud noise, usually greater than 120 dB (the level of an ambulance siren), can profoundly affect hearing (Bogardus et al., 2003). Acoustic trauma damages the hair cells in the organ of Corti (Canlon, 1988).

Other etiologies include vascular occlusion, viral infection, acoustic tumors, or barotrauma. Mumps infection, even if asymptomatic, and reactivation of the herpes simplex virus have been implicated. In most cases, the cause of sudden deafness cannot be identified (Nakashima et al., 1998).

The effect of therapy is difficult to evaluate because spontaneous improvement in hearing is common. The standard treatment in the US is steroids, while hyperbaric oxygenation has been used with favorable results in Japan for more than 30 years (Nakashima et al., 1998). Although this treatment may be of benefit months after the onset of symptoms (Schumann et al., 1990), early treatment is more likely to be effective (Lamm et al., 1998). As with any condition, alertness of the clinician may avert missed opportunities for optimal intervention.

The Politzer Maneuver (The Fistula Test)

1. In cases of chronic suppuration of the middle ear, the Politzer maneuver can be used to check for the presence of a fistula through the horizontal semicircular canal. A Politzer bag fitted with an atomizer tip is used to compress the air in the external canal. If a fistula is present, the patient will develop vertigo, and usually nystagmus. (A false-negative test may occur if the labyrinth is dead.) This test may be performed in all patients with chronic middle ear infections, especially if there is a history of vertigo. If a fistula is present, infection may track from the middle ear and the mastoid into the inner ear, causing complete deafness and eventually meningitis (Adams et al., 1978).
2. The Politzer maneuver was also used in the predecongestant era to clear the eustachian tubes, especially in the negative form (i.e., using negative pressure from the Politzer bag to suck the pus out).

Unfortunately, now, the student may be able to find a Politzer bag only in a museum. It consists of a rubber bulb, described as pyriform or pear shaped, 4.5 in. in length and with a maximum diameter of 3.5 in. and with a screw-on straight-tipped nozzle. One is pictured on the Web site of the Mamiya Medical Heritage Center of the Hawaii Medical Society. The physician could improvise. Such simple bedside technology can instantly make a diagnosis that can be confirmed with sophisticated technology, if available (V. L. Goltry, *personal communication*, 2004).

Vertigo

The differential diagnosis of vertigo includes causes in the labyrinth; special maneuvers relevant to this complaint are discussed in Chapter 26.

Quantitative Characterization of Tinnitus

The characteristics of tinnitus include its intensity, range of frequencies, and degree of annoyance.

The audiologist records the tinnitus in decibels by matching it with the loudness of the sound required to mask it. The otolaryngologist/neurotologist uses an intensity scale from 0 to 7, with 0 being no tinnitus and 7 being the most severe intensity reported by the patient (Shulman, 1992).

The annoyance factor, which may not be strongly correlated with loudness, is rated by the patient as "slight," "moderate," or "severe." "Slight" means not very severe, not constant, and usually bothersome only in a quiet environment. "Moderate" tinnitus is more intense and constantly present, interferes with concentration, and disturbs sleep. "Severe" tinnitus is incapacitating (Møller, 1994).

Tinnitus generally encompasses sounds of various frequencies, which may be matched with sounds of known frequency, for example, on a test compact disk manufactured by Stereophile, P.O. Box 5529, Santa Fe, NM 87502.

Precisely characterizing the tinnitus permits the generation of sounds appropriate for masking it. Measurements also provide a more objective assessment of response to therapy, as in the case report below.

Self-experiment on Treatment of Tinnitus: A Case Report

A 41-year-old physician experienced acute acoustic trauma as a result of using an electric drill on sheet metal in an enclosed space.

He noticed the immediate onset of severe tinnitus. The diagnosis of cochlear hydrops was made on the basis of electrodiagnostic cochlear vestibular testing. No therapy was recommended except for steroids.

The physician discovered in the course of a MEDLINE search that hyperbaric oxygenation is the treatment of choice outside the US, and he persuaded a physician to prescribe an off-label use of this modality (Marsteller, 2004). He received 15 treatments at 2.4 atmospheres absolute (ATA) for 90 minutes each. He monitored the amplitude of white noise needed to mask his tinnitus using a sound level meter obtained from Radio Shack (Fig. 11-5). The initial intensity was about 70 dB, and the frequency as determined by comparison with a white noise test track was 60 Hz and higher. He also used an expedient method suggested by the fortuitous presence of a very noisy vending machine near the hyperbaric chamber. He counted the number of floor tiles between the machine and the point at which its noise masked his symptoms. He found that the intensity of his tinnitus decreased after a treatment, increased somewhat between treatments, and then regressed a little more after the subsequent treatment. Before starting treatment, the tinnitus was disabling despite the use of prednisone. At the conclusion of the treatments, he had a mild residual tinnitus that eventually resolved.

Figure 11-5 A sound level meter that can be used to measure the intensity of sound required to mask tinnitus.

Three years later, after listening to a loud musical performance, the physician had a recurrence of symptoms. He started prednisone at 60 mg per day and noticed a slight improvement over about a week. He then initiated a series of treatments in the chamber pictured in Fig. 11-6, which was more convenient and less expensive than the hospital's chamber, although capable of delivering only about 1.25 ATA pressure, with oxygen supplied by an oxygen concentrator via a nonrebreathing mask. His initial masking level was 55 dB and the major frequency components of the tinnitus were 60 Hz and 10 kHz. After the first session, the most annoying "buzzing" harmonic was gone and did not return. After about 12 sessions, the masking intensity was 35 dB; the frequencies were 5 and 15 kHz, with 15 kHz predominating; the sense of fullness in the ears was less; and the annoyance level was reduced. Further improvement was experienced after ten sessions in a high-pressure (2.2 ATA) chamber, but symptoms worsened when prednisone was discontinued. Therefore, a short course of high-dose prednisone was reinstituted.

With intermittent low-pressure sessions, the physician was able to taper and discontinue prednisone with stabilization of symptoms at a masking level of around 36 dB.

It was necessary for the physician to buy a more sensitive sound level meter as the Radio Shack meter could not read below 50 dB. Additionally, as he improved, measurements could be made only at unusually quiet times. The background sound in a "quiet" office is about 50 dB and, in a residential neighborhood at night, about 40 dB (Bogardus et al., 2003). Turning on a water faucet was found to be an expedient generator of white noise of variable intensity.

A Note on Sound Intensity

Sound intensity I is generally expressed in decibels above the standard threshold of hearing I_0, where

$$(\text{dB}) = 10 \log_{10}[I/I_0].$$

The decibel scale is a reflection of the logarithmic response of the human ear to changes in sound intensity. A sound ten times as intense will sound about twice as loud. The just noticeable difference in sound intensity is about 1 dB for the normal human ear,

Figure 11-6 A portable hyperbaric chamber pressurized with compressed air and fitted with an oxygen concentrator that supplies oxygen to be administered by nasal cannula or nonrebreathing mask. (Photograph by Patti Wylie, with permission.)

dropping to 0.5 to 0.33 dB for very loud sounds. See Table 17.1 for levels of noise from common sources.

Appendix 11.1

Earlobe Crease: Sensitivity, Specificity, and Predictive Value

Answers to questions on pages 224 and 225:

If the numbers in the Pasternac and Sami (1982) study were diluted with persons who had no coronary artery disease, sensitivity would not change. Sensitivity is only concerned with how good the sign is in a population of persons who actually have the disease.

Specificity would not change because both true negatives and false positives would increase proportionately. Thus, sensitivity and specificity may be said to be "prevalence-free" statistics. This is another way of saying that they can be misleading if the study population is not representative of the usual population. Positive predictive values, in contrast to the other values, would go down. In the usual population, the positive predictive value of the earlobe crease is far less than 91%. Consider the formula for positive predictive value (true positives/[true positives + false positives]). Of its terms, only the false positives would increase, as patients without the disease are added to the study population. That means that the denominator, but not the numerator, will increase, so the positive predictive value will decrease.

From the world literature review, the sensitivity of the earlobe crease for coronary artery disease was 61%, the specificity was 71%, and the positive predictive value was 62%. For Elliott's cases, the sensitivity was 73%, the specificity 84%, and the positive predictive value 74%. The predictive values of a negative test, defined as (true negatives/[true negatives + false negatives]), were 70% and 84%, respectively.

Appendix 11.2

Testing the Diagnosis of a Blocked Eustachian Tube

This diagnosis could have been tested by (a) Valsalva maneuver, (b) Politzer maneuver, or (c) decongestants as a therapeutic–diagnostic trial.

Appendix 11.3

Answer to Question in Legend to Fig. 11-4

The score is the "Ode to Joy" from the final movement of Beethoven's Ninth Symphony. Beethoven's third and greatest period coincides with the time when he became stone deaf. "Much of the greatest music that ever influenced millions of people flowed from the mind of a man who never heard any of it" (Kubba and Young, 1996), at a time when he also suffered severe ill health and apparent mental deterioration. In his will, Beethoven reproaches his associates for thinking him pugnacious, stubborn, and misanthropic, not knowing of the condition that caused him to isolate himself from human society. He was able to conduct, and be annoyed at lack of attention to musical nuances, at a time when he was no longer able to converse (van Beethoven, 1911).

Some think that Beethoven's deafness resulted from Paget disease. Kubba and Young (1996) dispute this and suggest that he suffered from the most common cause, a mixture of nerve deafness and otosclerosis.

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CHAPTER

12

The Nose

I tell you, the old doctor who could cure you of every illness has all but vanished and you find nothing but specialists these days.... If you have something the matter with your nose, for instance, they'll send you to Paris....The specialist looks inside your nose and announces:Well, all right, I'll take care of your right nostril, but I really don't handle left nostrils; for that you'll have to go to Vienna where there's a really great left-nostril specialist.

—Fyodor Dostoyevsky, *The Brothers Karamazov*, Part Four, Book Eleven, Chapter 9

Points to Remember:

- The nose is affected by systemic or local conditions involving skin, cartilage, bone, and mucous membranes. Sometimes an "elevator diagnosis" can be made by looking at the nose.
- Signs of congenital conditions, trauma, or drug abuse may be prominently displayed on or in the nose.
- In a patient with rhinorrhea, the most critical diagnosis not to miss is a cerebrospinal fluid leak.
- Impairment of the sense of smell may occur in endocrine, neurologic, metabolic, congenital, nutritional, infectious or postinfectious, neoplastic, or autoimmune conditions, as well as trauma or conditions localized to the nose.

External Appearance

The bulbous swollen nose of rhinophyma (a variant of acne rosacea) permits an "elevator diagnosis" (Fig. 12-1). The term comes from the Greek word *rhino*, which means nose, and *phyma*, which means growth. Rhinophyma involves a proliferation of connective tissue, which occurs with long-standing rosacea. There is a relationship between a tendency for pronounced facial flushing and the development of acne rosacea (Swerlich and Lawley, 1994). Rhinophyma has a statistical association with ingestion of alcohol and other vasoactive influences such as a hot climate. However, the sign is of unknown specificity and, as most patients with alcoholism do not have it, of low sensitivity to alcoholism. An association with basal cell carcinoma has been clearly established (Roenigk, 1987).

Saddle nose is caused by the erosion of the bony portion of the nose. It is seen in congenital syphilis (Fig. 12-2).

An appearance similar to the saddle nose, but actually caused by destruction of the cartilaginous portion, is also seen in what other disease? (If you are reading this work in sequence, you have already come across this disease in Chapter 11, with the advice that you learn to cross-refer readings in this work with those in your favorite medical textbook.)

Destruction of the tissue of the external nose may be caused by basal cell carcinoma or by the gummas of late syphilis (Fig. 12-3).

The nostrils flare during normal respiration only in diseases of the chest or in those abdominal conditions touching on the diaphragm (Silen, 1979).

Midline granuloma can completely destroy the nose and other central facial structures including bone. At this stage, it is not usually a diagnostic problem. Leprosy, fungi, trauma, and tumors may also destroy the external nose, though they are less devastating to other structures than midline granuloma is.

Nose piercing for decorative purposes may cause infection and swelling, particularly if the stud is retained within the tissues. If the stud penetrates the lateral nasal cartilages, there is the possibility of perichondritis and necrosis of the cartilage, leading to alar collapse. In most cases, simple removal of the retained stud leads to uneventful healing (Watson et al., 1987).

Internal Appearance

Methods of Examination

The internal examination of the nose may be performed with (a) an otoscope with the nasal speculum inserted in place of the ear speculum, (b) a handheld Vienna nasal speculum (the type that opens when you squeeze the handle), or (c) simply a light and one's fingers. Most nonspecialists do not use the Vienna speculum, with or without a head mirror, so they are not able to do as detailed an examination as the specialist. Students should seek opportunities to work in the ear, nose, and throat (ENT) clinic and practice the use of a head mirror. (Mastering the technique requires a great deal of practice. Dr Douglas Lindsey of Arizona suggests assembling model airplanes in the focal point of light from a head mirror.) Outside the clinic or office, a head mirror is impractical, and a penlight or otoscope with the nasal speculum must suffice.

Use of Otoscope with Nasal Attachment

1. Place the nasal speculum on the otoscope head and turn on the light.
2. With your nondominant hand, push the tip of the nose lightly up so as to make it easier to introduce the nasal speculum into the nostril. (The dominant hand is used to position the patient's head, manipulate instruments, or to hold the light if you do not have a head mirror.)

Figure 12-1 Rhinophyma. *Potrait d'un Vieillard et d'un Jeune Garcon* (*Portrait of an Old Man and His Grandson*) by Ghirlandaio, the Louvre. (Courtesy of the Réunion des Musées Nationaux, Paris, France, with permission.)

3. Observe the color of the nasal mucosa, and check for ulcerations.
4. Check the septum for deviation or perforation.
5. If possible, visualize the middle and inferior turbinates. Check the middle meatus for purulent discharge or polyps.
6. Repeat the examination for the other nostril.
7. Clean the nondisposable plastic nasal speculum with soap and water, and then soak it in a 10% solution of sodium hypochlorite (bleach) for 15 to 20 minutes. (Alcohol has also been used for this purpose, but bleach is effective for killing viruses, such as those of hepatitis and the acquired immunodeficiency syndrome [AIDS].[1] It is best to use a disposable speculum.)

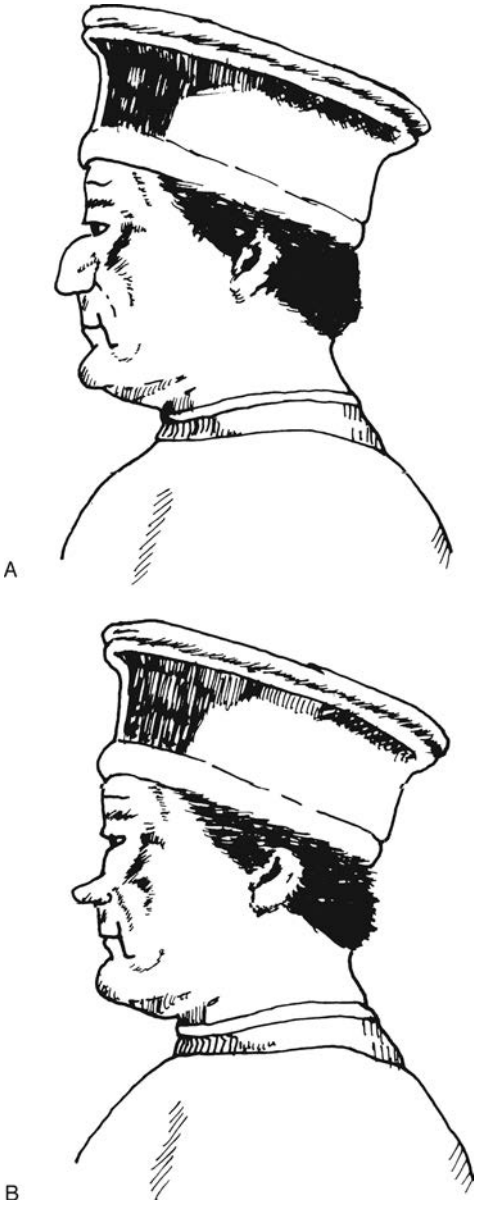

Figure 12-2 **A:** A false positive for the saddle nose of congenital syphilis. (Redrawn from the portrait of the Duke of Urbino [Federigo Da Montefeltro] by Piero della Francesca in the Uffizi, Florence.) **B:** How the Duke's nose would have looked if he truly had had congenital syphilis.

Figure 12-3 Gummatous involvement of the nose mimicking basal cell carcinoma. (From U.S. Public Health Service. *Syphilis: A Synopsis*. Publication no. 1660. Washington, DC: U.S. Public Health Service; 1968, with permission.)

Use of Vienna Nasal Speculum

1. To expedite the examination, especially if a disease of the nose is suspected or if the membranes are swollen, use 0.5% phenylephrine (as a spray or applied with cotton) to shrink the membranes.
2. Hold the speculum in your nondominant hand.
3. Insert the speculum so that it opens in an up-and-down direction, stabilizing it by placing your forefinger on the side of the patient's nose.
4. Inspect the intranasal structures in turn, as described above.
5. Clean the metal speculum with soap and water, then soak it in a disinfectant solution (preferably 10% sodium hypochlorite) for 20 minutes, or boil or autoclave it for 15 to 20 minutes.

The Nasal Septum

A Method

If you are concerned about the possibility of a septal perforation, you may wish to perform the following special test:

1. In a darkened room, shine a light in one nostril (as with the otoscope and nasal speculum).
2. Look up the other nostril and see whether the beam of light shines through the septum. (This is not simply transillumination, which may occur normally if the light is sufficiently strong.)
3. Repeat from the other side.

Causes of Perforation

Septal perforation can result from trauma ("Major," Delp and Manning, 1975); chromium poisoning (Leopold, 1952); infection, including tuberculosis (DeGowin, 1965), infected intranasal hematoma, and syphilis (once the most common cause) (Adams et al., 1978); cocaine or heroin inhalation (Sapira and Cherubin, 1975);

[1] As the AIDS virus has been isolated from tears (CDC, 1985) and tears drain into the nose, it is presumably present in nasal secretions.

and a variety of connective tissue diseases, including Wegener granulomatosis, midline granuloma, systemic lupus erythematosus, mixed cryoglobulinemia, rheumatoid arthritis, psoriatic arthritis, progressive systemic sclerosis, and mixed connective tissue disease (Wilkens et al., 1976).

Deviated Septum

Trauma is the usual cause of a deviated septum. As with most nasal findings, the history should have drawn your attention to it.

For the Attending. The Latin word *saeptus* is from the perfect participle passive of the verb *saepire*, meaning to erect a fence or enclosure or hedgerow (Kidd, 1979). This masculine noun means "wall." For some reason, this has become septum in English, which would be a neuter noun were it Latin. The plural of septum would, were it Latin, be septa. However, the incorrect plural septa has been mistaken as the feminine singular by a certain hepatologist, who created still another plural, septae. (Actually, as septum is an English word, the plural should be septums.) However, usage governs language, hence the "Latinically" incorrect title of this section.

The moral of the story is that once the masculine gender has been neutered, as with any castration, there is no going back.

Nasal Mucosa

Patients suffering from allergic rhinitis (or just recovering from an upper airway infection) may have a pale, boggy-looking nasal mucosa, or the mucosa may appear red and swollen, depending on the phase of the illness (Adams et al., 1978). A dry, red appearance, often with marked swelling and airway obstruction, is seen with overuse of topical decongestants. The mucus may be purulent in upper airway infections or sinusitis. Streaks of blood may be present after trauma, epistaxis, or repeated nose blowing.

Nasal signs and symptoms are most helpful in combination with other findings in diagnosing sinusitis. Considering the findings of maxillary toothache, purulent nasal secretions, poor response to decongestants, any abnormality on transillumination, and a history of colored nasal discharge, the likelihood ratio for sinusitis is 6.4 if four or more are present, 2.6 if three are present, 1.1 if two are present, 0.5 if only one is present, and 0.1 in the absence of any of these findings (Williams and Simel, 1993).

Polyps are relatively common masses within the nasal cavity that have the appearance of peeled grapes. They may arise from the nasal mucous membrane of the turbinates or come from the paranasal sinuses. They may be distinguished from a swollen turbinate or tumors by the fact that they are mobile and painless to touch. They are the result of any chronic irritation, which is usually caused by an allergy, but may be due to recurrent infection. There is a triad of aspirin sensitivity, nasal polyposis, and asthma, although this finding is not common (Adams et al., 1978).

Differential Diagnosis of Rhinitis

Allergic rhinitis is the most common type of rhinitis. It can be seasonal, perennial, or occupational. It is considered a systemic illness and may be associated with constitutional symptoms such as malaise, fatigue, and headache, or be a comorbidity in patients with asthma, chronic sinusitis, or eczema. Sneezing, nasal itching, "allergic shiners" (dark areas under the eyes), and concomitant asthma suggest an allergic cause. Prominent congestion, postnasal drip, and loss of smell and taste can occur with either allergic or nonallergic rhinitis. The latter includes vasomotor rhinitis, rhinitis medicamentosa from overuse of decongestants, and drug- or hormone-induced rhinitis (Quillen and Feller, 2006).

Other Findings in the Internal Nose

Benign or malignant tumors may be seen in the nose. They are painless and usually do not bleed. Unilateral rhinorrhea can be due to foreign bodies such as peas, beans, or nuts, usually found in the pediatric age group, but is also caused by choanal atresia and unilateral sinusitis. If unilateral rhinorrhea has no obvious cause, a cerebrospinal fluid (CSF) fistula (*vide infra*) should be sought (Prior and Kenyon, 1997).

The paranasal sinuses, nasal cavity, and mouth are primary sites of infection with *Aspergillus*, the second most common fungal infection in patients receiving cancer chemotherapy. Lesions are black, ulcerated, and escharotic as a result of tissue destruction and thrombotic vascular infarction. Greenish, firm, gelatinous material may be seen in the nasal cavity, and the nasal discharge contains white or brown particulate matter with fungal elements. Fistulous tracts from the paranasal sinuses may open on the face (Dreizen et al., 1992).

Cerebrospinal Fluid Rhinorrhea

A clear watery liquid dripping from the nose suggests the diagnosis of CSF rhinorrhea (Anderson et al., 1961; Prior and Kenyon, 1997; Roberts, 1958). Although CSF rhinorrhea is most often a consequence of trauma, spontaneous (normal-pressure) CSF rhinorrhea does rarely occur, constituting 3% to 4% of CSF fistulas (Beckhardt et al., 1991). Such cases probably result from congenital dehiscences and the formation of small meningoceles. Nose blowing precipitated the onset in 30% of ten patients presenting with spontaneous CSF rhinorrhea (Tolley, 1991). Whatever the etiology, the connection between the subarachnoid space and the nose predisposes the patient to meningitis and may require surgical intervention.

Trauma victims with a fracture of the cribriform plate may have CSF leaking from the nose or mouth. This is often mixed with blood, which does not clot. Such nasal secretions should be evaluated by placing a drop on a piece of filter paper (or paper towel) to see whether it separates into a central red spot with a clear, straw-colored outer ring or "halo." (The halo is due to CSF.) Never place a nasogastric tube in a patient with this sign because it may end up in the cranial vault (Timberlake, 1986).

If CSF rhinorrhea is suspected, ascertain whether the rhinorrhea increases when the patient bends over or coughs; whether the patient chokes, especially at night; and whether handkerchiefs soaked in the discharge remain limp when dry (Prior and Kenyon, 1997).

Rhinorrhea with very high glucose levels (>30 mg per dL), approximating those in CSF (40 to 80 mg per dL), would tend to support the diagnosis of CSF rhinorrhea. Unfortunately, the glucose oxidase test tape, once recommended, is too sensitive for a bedside test, producing frequent false positives (Kirsch, 1967) due to the reducing substances found in tears. (Tears are relatively rich

in glucose and may enter the nose through the nasolacrimal duct.) A glucose level as high as 17 mg per dL was found in one case proved at surgery not to have CSF rhinorrhea (Crow et al., 1956). However, the trick may yet work using the new Chemstrip blood glucose strips (Ackerman et al., 1989). At present, laboratory quantitative glucose determination is said to be the most effective and least morbid method for confirming the presence of CSF (Beckhardt et al., 1991). The presence of beta-2 transferrin in the fluid is diagnostic (Prior and Kenyon, 1997).

Special Maneuvers: Sense of Smell

Although the examination of the first cranial nerve might also be considered part of the neurologic examination, it is included here because the cause of impairments in smell might be found on inspecting the nose.

The use of the doctor's sense of smell as a diagnostic tool is discussed in Chapter 13. Testing smell requires the use of a substance that is not irritating. Pepper and alcohol, for example, are not acceptable (especially as pure alcohol is odorless). My examining bag contains two plastic containers, one of ground cloves and one of cinnamon, both reasonably fresh. Other good test substances would be nutmeg, allspice, coffee, or mint.

A Method

1. Have the patient close his eyes and occlude one nostril while you uncap one of the plastic containers and hold it near the other nostril. Instruct the patient to take a deep breath.
2. Ask the patient whether he can smell anything, and if so, ask him to identify the substance.
3. As a control, leave the cap on the vial, and ask whether he can smell the substance.
4. Repeat the test with the other substance (uncapped) and the other nostril. Also, ask the patient whether the second odor was different from the first.

Interpretation

Most patients will not be able to identify the specific odors, and some may not be able to distinguish the two odors; what you are really trying to determine is whether they are aware of the odors at all. Thus, exclamations of partial recognition and frustration at being unable to name the specific substance are also evidence of intact olfactory function.

In patients who might be malingering or trying to fool the examiner for some other reason, watch for nostril flaring. Flaring of the nostrils is evidence that a bona fide attempt is being made, although it is more likely to be seen if the patient holds the object being sniffed than if the doctor does. The absence of nostril flaring tells you nothing.

A more accurate test is to have the patient smell an ammonia inhalant pearl or smelling salts. This substance stimulates the fifth nerve rather than the olfactory nerve. If the patient does not respond by drawing back or grimacing, then he is probably malingering (J. Boyles, *personal communication*, 1998).

Causes of Loss of Smell

Bilateral loss of smell always accompanies hypogonadotropic hypogonadism (Kallmann syndrome). Impairment or loss of smell may be seen in zinc deficiency, head trauma, multiple sclerosis, sarcoid, Parkinson disease, chronic renal failure, cirrhosis, pernicious anemia, Cushing syndrome, hypothyroidism, diabetes mellitus, Turner syndrome, primary amenorrhea (which might have been due to Turner syndrome), pseudohypoparathyroidism, cystic fibrosis, laryngectomy, acute viral hepatitis, bronchial asthma, and toxin exposure and may also be seen because of certain drugs (Delaney, 1983; Schiffman, 1983).

Local afflictions that produce bilateral loss of smell include Sjögren syndrome, adenoid hypertrophy, allergic rhinitis, nasal polyposis, sinusitis, leprosy, ozena, and influenza-like infections (Delaney, 1983; Schiffman, 1983; Wechsler, 1963). Inflammatory nasal disease and postviral disease were the most common causes in a series of 63 patients (Davidson et al., 1987).

Unilateral anosmia is very rare and is most often found in local afflictions, such as inflamed nasal mucosa, when they are worse on one side than on the other. It can, however, be an excellent sign for drawing attention to a frontal lobe tumor (Liddell, 1976). It is rare for trauma to affect the olfactory nerve on only one side.

For years, it was believed that the urinary odor produced (because of unusual methyl thioesters) after eating asparagus (White, 1975) was an inherited polymorphism because some subjects claimed not to excrete such odoriferous substances. However, it now seems that all persons excrete the substances, but the ability to smell the odors is polymorphous (Lison et al., 1980). The student should keep this sequence of theories in mind when considering less trivial researches.

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CHAPTER

13

The Oropharynx

Look to thy mouth; diseases enter there.
—George Herbert (1593–1632), *Church Porch*, Stanza 22

Points to Remember:

- In examining the mouth, the special method of olfaction may be employed. Lacking portable mass spectrometers to analyze the metabolic by-products found in the breath, we can still use our chemical senses, as premodern physicians did.
- The earliest signs of serious systemic diseases, such as regional enteritis (Crohn disease), AIDS, and Addison disease, may be found on careful examination of the mouth.
- Dental and periodontal disease can cause serious problems with general health.
- Hyperpigmentation of the oral mucosa can occur with heavy metals, many drugs, endocrine or hematologic diseases, as well as other conditions.
- Obstructive sleep apnea is very common. Findings on ENT examination may be subtle or absent, and a high index of suspicion is required.

Order of Examination

Inspection

The patient should sit up straight, facing the examiner, at a height such that the physician can comfortably look into the mouth. A flashlight or the otoscope may be used as a light source at the bedside, although the head mirror of the ear, nose, and throat (ENT) specialist provides superior illumination.

A Method

1. Inspect the lips (discussed later in this chapter), everting them to examine the labial mucosa. Ask the patient to open his mouth and inspect the oral aperture and then all the structures inside the mouth (with the dentures removed), including the dorsal surface of the tongue. Check for fibrillations and fasciculations of the tongue (for significance, see Chapter 26). This must be done with the tongue at rest and the patient breathing through his mouth. Most normal persons have "contraction fasciculations" when the tongue is held in forced extension. The method that involves the least amount of effort for the patient is for you to pull out his cheek by hooking your finger in the angle of the mouth, and then have the patient open his mouth slightly to permit inspection of the tongue at repose.
2. Use the tongue blade to retract the cheek and lips for a complete inspection of the buccal mucosa, the opening of the Stensen[1] and Wharton ducts (the former directly opposite the second molar and the latter just under the tongue about 5 mm lateral to the frenulum), the teeth, and the gums.
3. Ask the patient to place his tongue on the roof of his mouth to permit inspection of its under surface and the floor of the mouth (all common sites for carcinoma, especially in older smokers).
4. Next, inspect the palate (for findings, see later in this chapter). Use of an intraoral mirror is very helpful.
5. Ask the patient to relax his tongue. (Do not ask him to protrude it for this part of the examination—see Chapter 26.) If you cannot see well, depress the middle third of the tongue with the tongue blade in your nondominant hand, and if you still cannot see well, pull the tongue forward. Do not touch the posterior portion of the tongue; you do not want him to gag until you are ready to test the gag reflex (see Chapter 26). The tonsils, tonsillar fossa, the anterior and posterior pillars, the posterior and lateral pharyngeal walls, a portion of the base of the tongue, and occasionally the tip of the epiglottis (discussed later in this chapter) can now be seen.

An Alternate Method

Stand behind the seated patient and have him extend his neck, open his mouth fully, and hold his breath in deep inspiration. The tongue and floor of the mouth will drop with gravity; a tongue blade is seldom needed (Greally, 1988; Sprackling, 1988).

Any single black mucosal lesion in any part of the oropharynx could possibly be a malignant melanoma, and a biopsy should be performed.

Palpation

Palpate all symptomatic or unusual-appearing areas in the mouth and pharynx. (The examiner should wear disposable gloves.) In persons at high risk for carcinoma, the tongue and floor of the mouth should also be palpated because moderate-sized tumors and cysts lying deep within the oral tissues may be found only in this way. Calculi in the submaxillary ducts can be felt. (The salivary glands are discussed in Chapter 14.) A perfectly round, pale, subcutaneous mass in the floor of the mouth is due to the obstruction of a minor

[1] The Stensen duct is sometimes called *Steno duct*. It is not only the same duct, but also the same person, a Danish theologian (1636–1686). He was also the one who was the first to explain the functions of the ovary, to distinguish between stratified and volcanic rocks, and to understand the correct origins of fossils, though he is not memorialized for these achievements.

salivary gland; this is called a *ranula*. The temporomandibular joints can be palpated by placing your fingertips in the external ear canals and having the patient open and close his mouth.

Percussion

The tongue may be examined for myotonia by placing a tongue blade across the mandibular teeth, having the patient place his tongue on top of the tongue blade, and tapping on the relaxed tongue with a reflex hammer. The reflex hammer should be wrapped in a clean, disposable material. (See Chapter 25 for a description of myotonia as manifested in the hand.)

Olfaction

A Method

Ask the patient to count aloud from one to ten while you put your nose in the stream of exhaled air. If you have reasons to suspect a noxious odor, it is possible to turn your face away from the patient and still keep your nose in the stream.

Some patients have poor oral hygiene or have been vomiting so the breath odors are masked by those coming from the mouth. In that case, have the patient rinse out his mouth with a nonfragrant solution. With sufficient mouth care, one can reduce the odor sufficiently to be able to smell the breath that is actually emanating from the lungs.

Another method is to have the patient close his mouth. Place your nose where the steam would be if the patient were nose breathing on a cold day and smell the air as it exits from his nostrils. (To demonstrate to yourself that nose breathing decreases communication with the oral cavity, place a drop of peppermint oil on the tongue of a nose-breathing subject and see how well you can smell the peppermint with the subject's mouth closed and then open.)

Specific findings are given later in this chapter.

Oral Aperture

Normally, the mouth should open sufficiently to permit the introduction of the tips of the patient's three middle fingers, vertically aligned, without the fingers touching the lips. Three conditions in which the oral aperture is smaller are (a) tetanus (not usually a diagnostic problem); (b) various mechanical diseases of the jaw, especially disease of the temporomandibular joint; and (c) progressive systemic sclerosis (scleroderma). Dr Gerry Rodnan of the University of Pittsburgh charted the progress of systemic sclerosis by recording the patient's maximum oral aperture. The patient's mouth, opened as far as possible, was pressed against a piece of paper, such as a progress note sheet. Lipstick facilitated the measurement.

Lips

The most common deformity of the lips is seen in the cleft palate syndrome. Because of the resemblance to the lip of a rabbit, this was sometimes called *hare lip*, which has been absurdly transmogrified to "hair" lip. A hard lesion on the lip with a discrete edge could be molluscum contagiosum or a malignant epidermoid carcinoma. It usually requires a biopsy to make the distinction, although about 95% of labial epidermoid carcinomas occur on the *lower* lip.

A luetic chancre (a moist-centered ulceration) may occur on the lip. Such lesions are incorrectly stated to be confined to the upper lip. (If you suspect a luetic chancre, wear gloves and wash your hands carefully after touching it because the lesion will be teeming with live spirochetes, as can be seen by dark-field examination.)

The mucous patches of secondary syphilis may involve the lips, tongue, or cervix.

Leukoplakia (literally "white plate") is often a precancerous lesion on the lips as on other mucosal surfaces.

Fever blisters ("cold sores") are caused by the herpes simplex virus, usually type I. After the first infection, the virus inhabits the neural tissue in a latent form and recrudesces on the skin, usually at the vermilion border, sometimes triggered by another illness such as a pulmonary or upper respiratory infection. At first, there is a vesicle or vesicles containing clear fluid. In a few days, the vesicle ruptures, leaving a sore, inflamed, and infectious ulcer, which forms a crust and then heals without a scar. Primary herpes stomatitis involving the oral mucosa, especially the gingiva and tongue, is common in children but less so in adults. It may be quite severe.

Cheilitis is an inflammation of the lips characterized by vertical fissures. It may occur with regional enteritis; acrodermatitis enteropathica (inherited inability to absorb sufficient amounts of zinc from the diet); alcoholism; deficiency of pyridoxine, riboflavin, or folate; sprue; kwashiorkor; viral illness; oral candidiasis; hypervitaminosis A; actinic prurigo, an idiopathic photodermatitis of persons of American Indian ancestry (Lane, 1997); and iron deficiency anemia, with or without Plummer–Vinson syndrome (Beitman et al., 1981). The last may be associated with abnormalities of the nails (see Chapter 7).

Diffuse swelling of the upper and lower lips with mild discomfort is the most constant feature of the oral manifestations that occur in about 10% of cases of Crohn disease and that may precede systemic symptoms, sometimes by years. Granulomatous cheilitis signals the need for long-term surveillance (Eisen and Lynch, 1998).

Angular stomatitis, the reddening and cracking of the lateral corners of the mouth, may be seen as a benign condition in patients who drool. In children, it is given the specific name of *perlèche*. Although the condition has been stated to be diagnostic for riboflavin deficiency, the most common cause is *Monilia* (*Candida*). Angular stomatitis also occurs with anemia and lipstick allergy. I have seen it in upper respiratory viral syndromes in cold climates and been following the same regardless of climate.

Angular stomatitis must be differentiated from syphilitic rhagades (literally "cracks"); the latter are not just reddened and inflamed but are fully epithelized cracks, furrows, or ridges, radiating from the corners of the mouth, especially laterally. Rhagades, unlike angular stomatitis, are permanent. Formerly, a medical student could bet against rhagades and for angular stomatitis, but as we eat more wisely and love less so, rhagades may make a comeback.

In Peutz–Jeghers syndrome, adenomatous polyps of the intestine are associated with 10 to 20 pigmented maculae around the mouth and lips. The lesions are about 1 mm in size and like apple jelly in color. If the small, round, circumscribed lesions were red,

like senile hemangiomas or cherry-red spots, one would better diagnose Rendu–Osler–Weber syndrome (hereditary hemorrhagic telangiectasia).

In Stevens–Johnson syndrome, the upper and lower lips are extremely swollen and sometimes hemorrhagic. The onset is sudden, and the lesions are nontender. The most common etiology is drug reaction, especially to sulfonamides. It may be accompanied by swelling of the tongue and buccal mucosa.

Tongue

Macroglossia

A great deal has been written about macroglossia, which simply means a large tongue. However, the diagnosis of macroglossia is a matter of opinion because no normal values are available for tongue size. The macroglossia reported in 22% of patients with primary systemic amyloidosis may also be associated with visible changes and palpable stiffness (Kyle and Greipp, 1983), but in Down syndrome and myxedema, it is difficult to be sure how much is macroglossia and how much is simple protrusion.

Some authors have suggested that lateral teeth indentations upon the tongue are presumptive evidence of macroglossia. However, I have seen that finding in a number of patients thought to have neither a disease of the tongue nor any of the known causes of macroglossia, which additionally include neonatal hypoglycemia syndrome (Combs et al., 1966), gargoylism, generalized gangliosidosis, glycogen storage disease, Beckwith–Wiedemann syndrome, acromegaly, and pemphigus vulgaris (Milgraum et al., 1985).

Glossitis

Glossitis means inflammation of the tongue. It can be confusing because the appearance of the tongue is different at different stages of the disease (Beitman et al., 1981). First, there is papillary hypertrophy, then flattening, followed by granular fusion, and finally atrophy. At first, the color of the tongue may be ruddy, "beefy," or magenta, but when atrophy occurs, the tongue will become pale and smooth and shiny.

Causes of glossitis (some of which overlap) include regional enteritis; alcoholism; sprue; kwashiorkor; pernicious anemia; malabsorption syndromes; deficiencies of pyridoxine, thiamine, niacin, or riboflavin; amyloidosis; and (rarely) the carcinoid syndrome. In one study of patients with iron deficiency anemia, who had an average hemoglobin level of 8.7 g per dL, glossitis was seen in 17% (Kalra et al., 1986).

Haemophilus influenza type b (Hib) can cause an infective glossitis, a less serious condition than the epiglottitis caused by the same disease (*vide infra*). It is uncommon for other viruses or bacteria to involve the tongue (Schneiderman, 1990).

In geographic tongue, also called *migratory glossitis*, areas of denuded epithelium appear and are restored to normal, with the pattern changing over periods of a few days. The patient may suffer considerable anxiety from this otherwise harmless condition. Appearances similar to that of geographic tongue can occur in pustular psoriasis, in Reiter syndrome, and with the use of strong mouthwashes (Schneiderman, 1990). Chronic overgrowth of *Monilia* usually produces a white coating over the tongue but can in some cases have the appearance of a geographic tongue.

Black Tongue

A hairy black tongue secondary to broad-spectrum antibiotic administration is usually attributed to *Aspergillus niger*, a customarily harmless organism that quietly vacates this ecologic niche after antibiotic administration is stopped.

White Patches

Monilia spots, which look something like flecks of cottage cheese, can be scraped off, although that often leaves a denuded bleeding undersurface. Leukoplakia, by contrast, cannot be scraped off with a tongue blade because it is intrinsic. *Candida* or *Monilia* is the culprit in about 96% of chemotherapy-induced fungal infections and is a frequent presenting sign of human immunodeficiency virus (HIV) infection. Other sites commonly involved are the buccal, gingival, palatal, and pharyngeal mucosa, as well as the commissures of the lips.

Hairy leukoplakia is a distinctive lesion that occurs in persons seropositive for the acquired immunodeficiency syndrome (AIDS), who are at increased risk of developing frank AIDS (Centers for Disease Control, 1985; Hollander et al., 1986). It consists of white warty or corrugated projections, particularly on the lateral aspects of the tongue and cheeks (Mindel, 1987). Hairy leukoplakia also occurs in other immunosuppressed conditions, being about as common in kidney transplant recipients as in HIV-positive persons (Greenspan and Greenspan, 1996). It has been described in a patient with chronic renal failure (De Kaminsky et al., 1995) and in an HIV-negative asthmatic patient receiving systemic steroids (Zakrzewska et al., 1995).

Other Lesions

1. A smooth, round, red mass at the base of the tongue may be a lingual thyroid.
2. The tongue can become so red and inflamed that it resembles a strawberry. This appearance, due to the desquamation of the filiform papillae, may result from the erythrogenic toxin of scarlet fever or from other febrile illnesses, particularly in toxic shock and in Kawasaki disease in children.
3. Absence of the fungiform papillae has been associated with familial dysautonomia.
4. Mucosal neuromas, which may occur in Sipple syndrome (type II B or type III multiple endocrine neoplasia or adenomatosis syndrome), are illustrated in Fig. 13-1.
5. The location of indurated ulcers of the tongue can be diagnostically helpful. If they occur at the tip, in the midline, one should consider primary lues. Any midline-indurated ulcer, whether or not it is at the tip, could also be tuberculosis. Histoplasmosis is a rare cause of indurated midline tongue ulcers. An indurated ulcer located laterally is suggestive of cancer, but cancer almost never appears as a midline lesion. A ragged, painful lesion on the undersurface of the tongue suggests Behçet disease, although the lesions of this disease may also occur on the dorsal surface. Any collection of multiple indurated ulcers should suggest tuberculosis.

6. There are two types of tongue fissures, congenital and syphilitic. In the congenital case, most of the fissures are transverse. (They are of no clinical significance.) In syphilis, most of the fissures are longitudinal.
7. Mucous patches on the tongue frequently occur in secondary syphilis (Fig. 13-2).
8. Blanching of the tongue because of arterial insufficiency due to giant cell arteritis occurred for 5 to 10 minutes at a time in one unusual patient (Grahame et al., 1968). Emboli from bacterial endocarditis can cause portions of the tongue to blanch. Liebermeister syndrome is blanching of half of the tongue, as may occur in an air embolism.
9. Caviar lesions, resembling little globs of purple-black caviar (as from the sturgeon, not orange caviar from the salmon) or perhaps buckshot, occur under the tongue. These are varicosities in the superficial sublingual veins, and their only importance is that they may frighten patients who notice them while looking in the mirror (Bean, 1958).[2]
10. Erythematous candidiasis is less obvious than the white plaques of thrush or pseudomembranous candidiasis, but it is just as important as a marker of the progression of HIV infection. It manifests as smooth depapillated areas on the palate and dorsal surface of the tongue (Greenspan and Greenspan, 1996).
11. The tongue may also show the lesions of aphthous stomatitis, lichen planus, Peutz–Jeghers syndrome, and Rendu–Osler–Weber syndrome (hereditary hemorrhagic telangiectasia). White reticulated lesions and erosions clinically identical to lichen planus are the most characteristic changes in chronic graft versus host (GVH) disease and occur in up to one third of such patients. Onset of chronic GVH disease is between 100 and 400 days after transplantation (Eisen and Lynch, 1998).

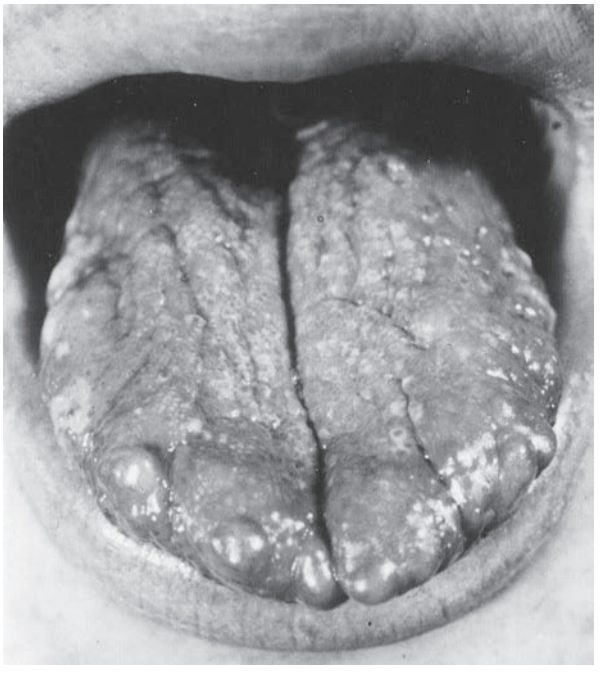

Figure 13-1 Mucosal neuromas are seen at the anterior edges of the tongue. Do not look for them at the base because the fungiform papillae might confuse you.

[2] The definitive study of vascular spiders and other skin lesions, written by a Chairman of Internal Medicine. This remains a model of clinical investigation.

Figure 13-2 Mucous patch of tongue due to secondary syphilis. (From U.S. Public Health Service. Syphilis: A Synopsis. Public Health Service Publication No. 1660, January 1968, with permission.)

Other Findings

Examination of the sense of taste and of the motor function of the tongue is described in Chapter 26. Examination of the sublingual veins is covered in Chapter 19.

Teeth

Color

Children who have had neonatal jaundice may have biliverdin green teeth later in life. Tetracycline administration (during pregnancy or infancy) may cause brown teeth. Fluorosis may cause brown-and-black pits. Red teeth are seen in erythropoietic porphyria but not in the more common acute intermittent porphyria. Dead teeth become slightly darker than the others.

Number

The teeth should be counted in any case in which a mysterious lesion appears in the jaw because it could be an odontoma. Dr Phil Bromberg of North Carolina first taught me the value of counting the teeth of a patient with a lung abscess—it is better if this is done before a tooth is found on the chest film.

Loose Teeth

Most cases of loose teeth result from tooth-and-gum disease but can result from jaw tumors or mercurialism. Periodontal disease

is characterized by gingival pyorrhea and gum recession, the latter being the origin of the term "long in the tooth" because it especially afflicts the senescent.

Dental Restorations

For more than a century, dental amalgam—a mixture of elemental mercury and a silver-dominated metal alloy—has been the most widely used dental-filling material. It has been a source of recurring controversy. Policy differences within Europe made dental amalgam a test case for the European Community's medical device regulations (Gelband, 1998). Austria, Germany, and Sweden advise restriction of amalgam use or its removal in certain situations (as for children or pregnant women), and some other nations restrict its use through environmental regulations (Wahl, 2001). In the US, extracted amalgam fillings or amalgam-containing teeth must be disposed of as toxic waste.

According to the American Dental Association (ADA), "Dental amalgam (silver filling) is considered a safe, affordable, and durable material that has been used to restore the teeth of more than 100 million Americans.... Issued in late 1997, the FDI World Dental Federation and the World Health Organization consensus statement on dental amalgam stated, 'No controlled studies have been published demonstrating systemic adverse effects from amalgam restorations'" (American Dental Association, 2002). The only side effects acknowledged by the ADA or the FDA are rare allergic or hypersensitivity reactions (U.S. Food and Drug Administration, 2002). Dentists are constrained against stating otherwise by the ADA code of ethics and the threat of sanctions by licensure boards. ADA Resolution 42H-1986 states: "the removal of amalgam restorations from the nonallergic patient for the alleged purpose of removing toxic substances from the body when such treatment is performed solely at the recommendation of the dentist is improper and unethical" (Odom, 1991).

Despite the widespread use of amalgam, there are no completed long-term large-scale studies of its health effects (Gelband, 1998). There are numerous case reports of severe systemic and neurologic symptoms that resolved upon removal of the fillings (Engel, 1998; Stock, 1926, 1939; Talbot, 1883). Additionally, oral and dental symptoms have been described, including loosened teeth, gingivitis, lichen planus, bleeding gums, and bone loss.

Quantitatively, dental restorations are the most significant nonoccupational cumulative source of human exposure to mercury. Mercury exposure averages from 3.9 to 21 μg per day as elemental mercury from dental amalgam, 5.3 to 10.3 μg per day from food sources, 4.3 μg per day as inorganic mercury, and 1 to 6 μg per day as methylmercury from fish (Aposhian, 2004). Additionally, certain vaccines contain up to 25 μg Hg per dose as ethylmercury from thimerosal. Clearly, there are wide differences in individual susceptibilities to any potential untoward effects. Moreover, there are many difficulties in the accurate measurement of the absorbed dose of mercury from amalgams (Eley, 1997a,b).

Count the number of amalgam surfaces in your patients' fillings. Be prepared to answer the questions of patients, especially those who frequent the Internet. Removal of fillings is not a procedure to be undertaken lightly.

Ask about and document the presence of endodontic restorations (root canals). These could serve as an asymptomatic nidus of infection, as nerves are destroyed in the procedure. Rare reported complications have included multiple liver abscesses (Schiff et al., 2003), precipitation of altitude sickness at a relatively low altitude (Finsterer, 1999), and recurrent pneumococcal bacteremia (Kragsbjerg and Rydman, 2001).

Other Findings

1. Lipstick adhering to the teeth suggests dry mucous membranes, for example, in the Sjögren syndrome (sicca syndrome).
2. Erosion of the enamel on the lingual, palatal, and posterior surfaces of the teeth because of frequent contact with gastric acid is a sign of bulimia (Mitchell et al., 1987).
3. Increased interdental spaces may be congenital or acquired, as in acromegaly.
4. Transverse ridging of the teeth may be seen in children with previous episodes of bone growth arrest due to deficiency of vitamin C or D.
5. Conditions of the teeth seen in congenital syphilis include the best-known Hutchinson teeth (Fig. 13-3). Hutchinson, an ophthalmologist, described the incisors as follows (Hutchinson, 1859):

   > On looking at his teeth, all doubt as to the real nature of the case was dispelled. The lower incisors, just cut, were large but presented singularly irregular edges, being thin and unequally serrate. The upper incisors were all deeply notched.

   These teeth are sometimes called the *notched teeth of congenital syphilis*. Sometimes there is no notching of the incisors, but the teeth are still short and thin and tapered like the tip of a screwdriver; hence, they are called "screwdriver teeth." The molars may also be involved in congenital syphilis. The crown may consist of an agglomerate of unusual enamel globules resembling a mulberry (Fig. 13-4), hence the name "mulberry molars."
6. Rampant decay seen with methamphetamine abuse ("meth mouth") is caused by the drug's enamel-eroding hydrochloric acid as well as the user's generally poor oral hygiene and consumption of sweet beverages owing to dehydration and sugar cravings.

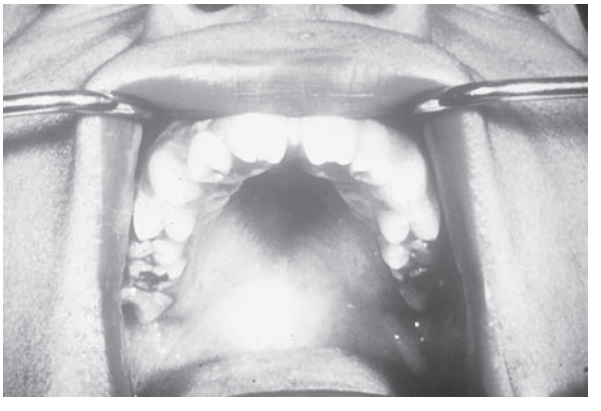

Figure 13-3 Congenital syphilis: Hutchinson teeth. Note the notched edges and "screwdriver" shape of the central incisors. (From U.S. Public Health Service. *Syphilis: A Synopsis*. Public Health Service Publication No. 1660, January 1968, with permission.)

Figure 13-4 Congenital syphilis: Moon's "mulberry" sixth-year molar of late congenital syphilis. (From U.S. Public Health Service. *Syphilis: A Synopsis.* Public Health Service Publication No. 1660, January 1968, with permission.)

7. Probing the area where the third molar should be can often lead to the detection of an impacted wisdom tooth, which can be the source of a low-grade fever of inapparent origin. The tooth is usually covered with a layer of gum under which bacteria feed on trapped food particles.
8. Fever of inapparent origin can also be due to an apical abscess. One may be able to find a single tooth that is sensitive to direct percussion. Alternately, one can screen all such patients with the Panorex, but the finding of tooth sensitivity is bound to increase the predictive value of this test if selectively ordered.

Gums (Gingiva)

All ulcerations of the mucosa may also affect the gums.

Hypertrophy of the gums in dentulous patients may be seen in chronic administration of phenytoin (diphenylhydantoin), leukemic infiltration (particularly monomyelocytic leukemia), scurvy, or (rarely) lues. Cyclosporine and any of the calcium-channel blockers may also induce gingival hyperplasia; the condition has most commonly been reported with nifedipine (Eisen and Lynch, 1998).

Bleeding of dentulous gums frequently results from periodontal disease. It also occurs in a variety of platelet defects, but it does not usually occur spontaneously with coagulation factor defects. Bleeding gums are seen in up to 93% of patients with scurvy but not in scorbutic patients who are edentulous (Vilter et al., 1946).

Periodontal conditions associated with the HIV infection include linear gingival erythema, possibly due to vasoactive cytokines; severe periodontal infections; and necrotizing ulcerative periodontitis (Greenspan and Greenspan, 1996).

The gingiva commonly appears healthy in periodontitis, giving no evidence of the destruction of the underlying supporting structures. Detection and diagnosis depend on a careful dental examination and radiographs. Bacterial growth and the consequent tissue destruction are facilitated by plaque and calculus on the teeth.

The possible role of periodontal disease in systemic conditions such as atherosclerosis and respiratory infections is a subject of investigation and controversy (Scannapieco and Genco, 1999). It could increase the risk of future cardiovascular disease by nearly 20%, with a 44% increased risk in persons aged 65 or under (Janket et al., 2003). Because about 30% of the American population has periodontal disease, the public health consequences could be significant (Slots and Kamma, 2001). It is worthy of note that about 50% of patients with coronary heart disease do not have one of the currently established risk factors, and there is increasing evidence of a role for inflammatory factors in atherogenesis (Armitage, 2000).

Pigmentation

Conditions that cause pigmentation of the mucosa (*vide infra*; Table 13.1) may also affect the gums. The normal pigmentation frequently observed in the oral cavity of nonwhite persons is distinguished by historic presence and uniform distribution; it is most prevalent in the gingiva and distinctly absent from the alveolar mucosa.

Acatalasemia causes black gingiva, with extensive ulceration.

Many systemic medications, notably the antimalarials, minocycline, amiodarone, and clofazimine, may cause a blue coloration of the oral mucosa, especially the hard palate and gums. The chronic administration of minocycline for acne may result in the blue-black discoloration of the alveolar bone; 20% of patients taking 200 mg daily developed this finding in 4 years (Eisen and Lynch, 1998).

A linear pigmentation of the gums may occur in dentulous patients with lead poisoning (Fig. 13-5). Look closely, and you will see that this early "lead line" is actually a series of stippled spots. To make a lead line more apparent, slip a small piece of white paper between the tooth and gum to serve as a background. Similar findings may occur with prior medical or industrial exposure to bismuth or mercury or with thallium intoxication (Grunfeld and Hinostroza, 1964).

Lead lines were frequently seen in Birmingham, Alabama, when unbonded whiskey was cheaply made from sugar, which was then quite inexpensive. Revenue agents used hatchets to destroy the expensive copper tubing of illegal stills. To keep costs down, the moonshiners began to purchase inexpensive junked automobile radiators as a substitute for the copper condenser coils. However, the radiators were soldered with lead, which adulterated the alcohol. When the price of sugar rose in the 1970s, the cost of moonshine escalated to a point at which some bonded alcoholic beverages became competitive. Lead lines then became rare.

Amalgam tattoos are the most common exogenous cause of oral pigmentation. Dental restoration materials such as amalgam may be inadvertently introduced into soft tissue, usually on the gingiva and alveolar mucosa, though more than 20% of such introductions occur on the buccal mucosa. They may appear blue, gray, or black (Eisen and Lynch, 1998). Usually, they can be distinguished from malignant melanoma by their macular character and lack of growth (Martin et al., 1989).

Palate

The palate appears to be high and arched in Marfan syndrome and in certain marfanoid disorders such as homocystinuria and Sipple syndrome (multiple endocrine neoplasia type II β or III).

TABLE **13.1** *Hyperpigmentation of the oral mucosa*

Origin	Comments
Exogenous	
Heavy metals	
Amalgam tattoos	See text
Lead	See text
Bismuth	Thin blue-black line surrounding teeth; also seen in other areas
Mercury	Diffuse grayish pigmentation of the alveolar gingiva; probably postinflammatory ulcerations, increased salivation, loosening of teeth, and periodontal destruction with chronic exposure
Arsenic	Widespread inflammation, especially of gingiva
Silver (argyria)	Permanent, diffuse bluish gray pigmentation with metallic luster, most commonly of hard palate
Copper	Blue-green line on gingiva
Cadmium, chromium	Deep orange stain of teeth and gingiva
Foreign materials	
Plant materials	Used by some as oral hygiene aids
Tobacco	Smoker melanosis, usually on mandibular gingiva
Alcohol	Areas of depigmentation surrounded by hyperpigmentation may be a useful screening tool
Gingival tattoos	For cosmetic purposes
Pharmacologic agents	See text
Fixed drug eruption	Antibiotics; heroin
Endogenous	
Endocrine disorders	
Albright syndrome; acromegaly	Reddish brown pigmentation
Addison disease	Hyperpigmentation in discrete macules or diffuse involvement of oral structures may be the first sign of disease
Other	Hyperthyroidism; hyperpituitarism
Hematologic disorders	
Hemochromatosis	Diffuse bronzing from hemosiderin deposition in 15% of cases
β-Thalassemia	Diffuse brown pigmentation from hemoglobin degradation products
Hereditary syndromes	
Neurofibromatosis	
Peutz–Jeghers syndrome	See text; while cutaneous hyperpigmentation fades in adulthood, persistence of intraoral pigmentation aids in making a definitive diagnosis
Carney complex	Cardiac myxomas, spotty pigmentation, and endocrine overactivity, transmitted as autosomal dominant; pigmented macules of lips present in 50% of cases
Other systemic conditions	
HIV	Adrenal insufficiency and pharmacologic agents contribute
Pulmonary disease	Pigmentation resembling melanotic macules on sides of soft palate are associated with pulmonary disease and bronchogenic carcinoma
Most nutritional deficiencies	
Acanthosis nigricans	Most frequently on tongue and lips; may occur in absence of skin manifestations; papillomatous growths on lips; hypertrophic filiform papillae of tongue; oral lesions, often not pigmented
Laugier–Hunziker syndrome	Rare benign syndrome distinguished from Peutz–Jeghers, Addison disease, and other conditions by lack of systemic findings
Neoplasms	
Melanotic macules	Well-circumscribed blue, black, or brown macules, usually less than 6 mm in diameter except on buccal mucosa, innocuous but may be excised because of inability to distinguish from malignant melanoma
Oral nevi	May be raised; malignant potential unknown; clinically indistinguishable from malignant melanoma
Malignant melanoma	
Reactive processes	
Oral melanoacanthoma	Almost all occur in blacks; may regress after removal of irritants; biopsy needed to distinguish from other causes
Postinflammatory hyperpigmentation	

HIV, Human immunodeficiency virus.
From Eisen D, Lynch DP. *The Mouth: Diagnosis and Treatment.* St Louis: Mosby–Year Book; 1998, with permission.

FIGURE 13-5 A lead line. The arrowheads indicate a portion of the "line," which is actually a series of dots. (Courtesy of Consultant, Cliggott Publishing Group of CMP Healthcare Media, Darien, CT, with permission.)

It is less widely appreciated than the palate of Down syndrome and is characteristically short and narrow, the latter aspect giving it the appearance of being high (Shapiro et al., 1967).

The torus palatinus is a congenital but not familial bony overgrowth of the midline suture of the hard palate, which protrudes down from the ceiling of the mouth. It is important to recognize this perfectly benign finding so as not to perform a biopsy of it in search of cancer.

Midline granulomas due either to the usual cryptogenic etiology or to syphilis, lymphoma, or exotic microorganisms can involve the palate.

Palatal defects can be a residual of unsuccessful surgery for cleft palate, radiotherapy for tumors, syphilitic gumma, or other necrotizing or infectious lesions. Tumors occasionally occur on the palate.

Dentures should always be removed so that the physician can inspect all of the mouth, but specifically, the upper plates should be removed as a quick test of capillary integrity and platelet function. The trauma caused by inserting and then removing dentures may result in petechiae of the hard palate, an early sign of thrombocytopenia or platelet abnormality.

Palate edema is seen in γ-heavy-chain disease (see the section entitled "Uvula," later on in this chapter).

The palate is the most common site for the oral lesions of Kaposi sarcoma in patients with AIDS. The lesions first appear as small red or purple patches; later, they become nodular and ulcerate if traumatized (Greenspan and Greenspan, 1996).

The abundant mucous salivary glands on the palate are a common site for minor salivary gland tumors, which are generally malignant. On inspection, they may resemble a torus palatinus, but palpation shows them to be firm rather than osseous.

The evaluation of motion of the soft palate is considered in Chapter 26.

Buccal Mucosa

Pigmentation

In patients with primary chronic adrenocortical insufficiency, the mucosa can develop spots of melanin, as if someone had sprinkled black fountain pen ink on the buccal mucosa. However, highly pigmented persons will often have large patches of buccal melanosis, especially opposite the molars. These are *not* the spots of chronic primary adrenocortical insufficiency.

Azidothymidine and ketoconazole can cause darkly pigmented patches on the tongue, buccal mucosa, and palate. Corticotropin (ACTH), busulfan, oral contraceptives, and phenothiazines may cause brown pigmentation of the various oral membranes (Eisen and Lynch, 1998).

Pallor

In one study, mucosal pallor was found in 30% of a group of patients with iron deficiency anemia and an average hemoglobin level of 8.7 g per dL (Kalra et al., 1986), but it was found in only 4% of another group of patients with non–iron-deficiency anemia whose average hemoglobin level was 10.32 g per dL.

Swellings

Exophytic mucous membrane tumors, with or without ulceration, are usually squamous cell carcinomas. Submucous round nontender tumors are usually disorders of minor salivary glands.

Xerostomia

In patients with xerostomia, the buccal mucosa will appear pale and dry because of epithelial atrophy and the loss of the mucous coating. Erythematous areas may be present. The tongue blade sticking to the oral mucosa is a crude but probably valid indicator of oral dryness. A quantitative method for measuring salivary secretions has been described (Sreebny and Valdini, 1987), but disease specificity is not well established. Associated findings in the oral cavity include fissuring and atrophy of the filiform papillae of the tongue, cheilitis, oral ulcers, candidiasis, dental caries, and an inability to express saliva from the ducts of the parotid and submandibular/sublingual glands.

Causes of xerostomia include radiation damage to the salivary glands from treatment of head and neck cancers, Sjögren syndrome (sicca syndrome), certain medications, GVH disease, pancreatic insufficiency, and type V hyperlipoproteinemia (Sreebny and Valdini, 1987). A biopsy of the labial salivary glands can show the focal lymphocytic infiltrates that are quite specific for Sjögren syndrome (Moutsopoulos, 1994).

The Dry Gingival–Labial Fold and Other Signs of Hypovolemia

Absence of saliva in the gingival–labial fold is positive evidence of dehydration, even in the patient who is mouth breathing. This is a more reliable sign than inspection of the buccal mucosa and tongue, which may become acutely dry because of mouth breathing, a frequent result of hyperventilation due to any cause.

Volume depletion is an emergent condition, and a number of other clinical methods, all of which are imperfect, have been proposed for detecting it:

1. Loss of the normal venous pressure, as seen in the jugular veins (see Chapter 19), is suggestive but limited; that is, the cervical venous pressure cannot be visualized in some persons, such as those with short or fat necks or veins that are inapparent for some other reason. So, in practice, the jugular venous pressure is useful only as an exclusionary sign for hypovolemia (i.e., when it is abnormally increased).
2. Orthostatic hypotension (see Chapter 6) is useful, but it presupposes the absence of neural problems, including those that result from drugs and drug withdrawal (especially from alcohol or other sedative–hypnotics). In addition, it requires that the patient be able to stand or that a tilt table be available.
3. Skin turgor assessment is discussed in Chapter 7.
4. It is said that dehydrated patients do not have axillary sweat.

The assessment is especially difficult if the patient has signs of excessive salt and water retention, leading one to assume that the patient is volume expanded. These signs include pulmonary edema, ventricular diastolic gallops, ascites, and edema. However, a patient with chronic ascites and pedal edema due to cirrhotic hypoalbuminemia might bleed and become hypovolemic without mobilizing all his "third space" fluid. In this instance, the absence of saliva in the labial–gingival fold is of great diagnostic utility; signs 2 and 4 may also be helpful.

Koplik Spots

Koplik spots are white, the size and color of grains of salt, each on an erythematous background, and are seen on the buccal mucosa, especially around the orifice of the Stensen duct and the lower labia. They are said to be pathognomonic for measles. However, ECHO virus 9 and coxsackie A16 infections may have oral mucosal spots just like Koplik spots (Artenstein and Demis, 1964; Hoeprich, 1972).

Vesicles, Bullae, and Ulcerations

Bullae appearing in the buccal mucosa in the presence of a diffuse bullous skin lesion in an elderly man should suggest the diagnosis of pemphigus, which is customarily and erroneously thought of as "just" a skin disorder. In fact, it may be a general medical emergency, requiring steroid therapy to prevent severe shock and hypoalbuminemia. Some of the bullous mucosal lesions appearing in the presence of bullous skin lesions turn out to be pemphigoid, Stevens–Johnson syndrome (erythema multiforme bullosum), Senear–Usher syndrome, erosive lichen planus, and so on. But because a patient with pemphigus can become very ill very fast, it is the one mucosal lesion that everyone should think about.

Primary herpetic gingivostomatitis, which produces numerous oral vesicles that rapidly ulcerate, is accompanied by systemic signs and symptoms. The differential diagnosis includes hand-foot-and-mouth disease, herpangina (due to coxsackie A virus), contact or allergic stomatitis (*vide infra*), and acute necrotizing ulcerative gingivitis.

Aphthous stomatitis is the most common cause of oral ulcers, aside from trauma. The benign but painful lesions have a grayish appearance on an erythematous base. They affect freely movable mucous membranes, such as those found on the tongue, the soft palate, the buccal mucosa, and the floor of the mouth. They have regular, smooth borders and are round to ovoid. Aphthous ulcers may be quite severe and prolonged in patients with HIV infection.

Ulcers of similar appearance may be associated with one fourth of cases of systemic lupus erythematous (Urman et al., 1978), Reiter syndrome, ankylosing spondylitis, inflammatory bowel disease, Behçet disease, cyclic neutropenia, and vitamin B_{12} deficiency (Burns and Davis, 1985); the first four tend to be oddly painless.

Aphthous ulcers must be differentiated from those of recurrent herpes simplex (Balciunas and Overholser, 1987). The latter generally involves the lip–skin junction but may affect circumscribed areas of the hard palate and gingiva, where the mucosa is firmly bound to the underlying periosteum. Herpetic lesions begin as vesicles and tend to occur in clusters. They are variable in shape and have somewhat irregular borders. In contrast, aphthous ulcers never begin as vesicles and do not occur in clusters, although they may be multiple.

Lesions that resemble large aphthae are the most consistent finding in Wegener granulomatosis. A less common but pathognomonic feature of this condition is a petechial and granular gingivitis, generally segmental, with a "strawberry-like" appearance.

Stomatitis medicamentosa, with widespread ulcerations and inflammation, may result from a wide variety of drugs, most commonly antibiotics, anti-inflammatory agents, anticonvulsants, antihypertensives, and antidepressants. Its clinical and histological features may resemble autoimmune diseases, such as hydralazine-induced lupus erythematosus, penicillamine- or captopril-induced lichen planus or pemphigus, and sulfonamide-induced erythema multiforme. A thorough drug history should be obtained as withdrawal of the offending agent may lead to complete resolution (Eisen and Lynch, 1998).

Contact stomatitis may be caused by a wide array of substances, including mouthwash, dentifrices, chewing gum, and components of dental appliances and restorations. Allergy to cinnamon compounds is one of the most frequent causes. The allergic reactions may mimic features of oral diseases.

Pyostomatitis vegetans is considered to be a highly specific marker for inflammatory bowel disease. Minute miliary pustules, primarily on the labial mucosa and gums, develop on an erythematous base. Rupture leads to erosions and ulcerations, forming the pathognomonic "snail track." When the diagnosis is confirmed by histopathology, gastrointestinal evaluation is warranted, as the oral manifestations may precede symptomatic bowel disease. Ulcerative colitis is the most common associated condition, but Crohn disease, primary sclerosing cholangitis, or other liver conditions may also be found (Eisen and Lynch, 1998).

Erosive oral lichen planus may be associated with chronic active hepatitis C.

Of all the fungi, histoplasmosis is the only one that produces shallow ulcers on the mucous membranes.

Smokeless Tobacco Lesions

Smokeless tobacco use can cause a variety of oral lesions. Gingival recession may occur, often with destruction of the underlying alveolar bone. Teeth that come into contact with the product

are more likely to develop caries, possibly because of the added sugar. Staining of the teeth and erosion of the enamel are common. Tobacco pouch hyperkeratosis is found in 10% to 20% of users of chewing tobacco and in about two thirds of snuff dippers. The mucosa appears grayish white, has an indistinct border, and is frequently surrounded by erythema. The lesions are asymptomatic, and patients are often unaware of their presence. The frequency is increased by concomitant use of betel leaves, slaked lime, and areca nuts. Biopsies should be performed on lesions that develop marked thickening or other signs of malignancy such as ulceration, induration, or rapid change. Nonmalignant keratoses should resolve within 2 to 3 weeks of ceasing tobacco use.

Smokeless tobacco use has tripled in the last 20 years and is especially prevalent in Southeast Asia and the Indian subcontinent. Nearly 5% of the world's population may now indulge in the habit. The substance is extremely addictive and carcinogenic, with a lifetime risk of cancer of about 5% (Eisen and Lynch, 1998).

In certain areas, predominantly Sweden, the pattern of tobacco use is changing. While the overall prevalence of tobacco use among Swedish men was stable at about 40% between 1986 and 1999, the percentage of smokers decreased from 23% to 14% and the percentage of users of Swedish moist snuff (snus) increased from 18% to 27% (Rodu et al., 2002).

Although not encouraged by U.S. antismoking campaigns, some inveterate smokers who are unable to quit may choose smokeless tobacco as an alternative nicotine delivery system that is substantially less expensive and more satisfying than nicotine patches or chewing gum (Rodu and Cole, 1999). It is estimated that about 2 million persons have used this method (Tilashalski et al., 1998). The 15-day reduction in life expectancy resulting from smokeless tobacco use compares favorably with the 7.8 years lost by the average smoker (Rodu and Cole, 1994). Oral cancer is the one consequential health risk of smokeless tobacco, but the risk is only 50% of that incurred by continuing to smoke (Rodu and Cole, 1999).

Be sure to look for early cancerous changes inside the upper lip of snuff dippers.

Other Mucosal Lesions

1. Leukoplakia may be associated with chronic irritation, as from cheek biting or smoking. This is a premalignant lesion.
2. Lichen planus is the most common dermatologic disease with oral lesions. Oral lesions are present in 30% to 40% of cases and are the only lesions in about 25% (Adams et al., 1978). The skin lesions are violaceous plaques with a fine scale, primarily on the flexor surfaces of the arms and legs. The oral lesions vary from well-defined white lesions to diffuse erythematous lesions to ulcerations. A fine network of radiating white lines called *Wickham striae* is diagnostic when present (Balciunas and Overholser, 1987).
3. Erythroplakia is a premalignant lesion of the oral cavity. It appears as a slightly raised, red, granular area that is friable and bleeds easily. It usually occurs on the anterior tonsillar pillars, soft palate, tongue, and retromolar trigone. It has a much greater tendency toward malignancy than leukoplakia and displays carcinoma in situ early on.

Noma

Noma (from the Greek *nome*, "spreading ulcer") is a gangrenous stomatitis due to synergistic aerobic and anaerobic bacteria. It may begin in a herpetic ulcer or other mucosal break and then spread to become a putrid exudative round ulcer with a necrotic middle. If untreated, it may actually eat a hole in the cheek and can then spread across the face and eventually kill the patient. Although often a disease of malnourished and weakened children, it may also occur in adults and has even been a cause of death in a primate colony during an outbreak of simian AIDS (Schiødt et al., 1988).

Throat

Uvula

Abnormalities of the uvula itself are rare except for the congenitally bifid uvula, which should suggest submucosal cleft palate, especially if there is a history of recurrent otitis media. Otherwise, it is only of aesthetic interest.

Displacement of the uvula is a sign of peritonsillar abscess or neurologic disease (see Chapter 26). The Müller sign is a uvular pulsation synchronous with systole; it occurs in aortic insufficiency and other conditions that produce a wide pulse pressure and high stroke volume (see Chapter 17). Sometimes, the uvula does not pulsate but merely flushes and pales in time with the heartbeat (Stone, 1986). The sign is insensitive; most patients with aortic insufficiency do not have it.

Swelling of the uvula has been reported in association with pharyngitis, either primary (owing to viral or bacterial infection) or secondary and iatrogenic (as in hospitalized patients receiving strong medicaments by inhaler). Uvular swelling is also seen in about one fourth of the patients with γ- (but not α-) heavy-chain disease (Seligman et al., 1979) and in the sleep apnea syndrome (Fig. 13-6) in which the uvula may also rest on the base of the tongue during phonation (Viner et al., 1991).

Figure 13-6 A large uvula in a patient with obstructive sleep apnea. (Photograph courtesy of Dr John Shepard Jr of Minnesota, with permission.)

Pharynx and Tonsils

Pharyngeal erythema is commonly seen in viral infections such as the common cold, the exanthems, and the influenza.

An exudative pharyngitis, which may show white or yellow follicles on the tonsils, suggests a bacterial infection due to streptococci but can also be seen in viral infections, especially infectious mononucleosis.

Peritonsillar abscess, much less common in the antibiotic era, is a surgical emergency. The throat pain may be so severe that the patient spits out his saliva. Even opening the mouth may be painful, and there may be trismus. The tonsil is pushed toward the midline, and the uvula is displaced.

Retropharyngeal abscess causes a retropharyngeal swelling, which, unfortunately, is not always perfectly apparent.

Ulcerative pharyngeal lesions may be the presenting sign of leukemia or agranulocytosis.

White spots on the posterior pharyngeal wall are usually either patches of *Monilia* (which are not easily dislodged by the tongue blade and leave bleeding patches when they are) or the residual curds of cottage cheese or ricotta (which are easily dislodged by the tongue blade and do not leave bleeding patches). A patient with Hodgkin disease and symptoms of an upper respiratory infection was admitted to determine whether there was another cause for his fever. White patches seen on the posterior pharyngeal wall led to an ophthalmologic consultation to look for fungal endophthalmitis (not present) and plans for a bone marrow aspiration for material to culture for fungi. The latter was canceled when it was discovered that the white patches had appeared after a meal of cottage cheese and had disappeared after the subsequent meal.

Membrane formation characteristically accompanies diphtheria.

A pseudomembrane covering the oral lesions may be seen in oral gonorrhea. Most patients with oral gonorrhea are asymptomatic. Manifestations range from mild pharyngeal erythema to severe mucopurulent discharge. Other parts of the mouth may be involved, with erosions of the lips, diffuse ulcerations, and desquamation and edema of the gingiva.

Epiglottis

A red, edematous epiglottis occurs in acute epiglottitis, a medical emergency. It may be seen on examination of the pharynx or only with indirect or fiberoptic laryngoscopy. It may produce the "thumb sign" on lateral cervical spine radiographs; a 12% false-negative rate has been reported (Solomon et al., 1998). The course is often fulminant, especially in children. If the diagnosis is suspected, the physician must be prepared to establish an airway, if necessary, with tracheotomy. Even an attempt to examine the throat could precipitate complete airway obstruction. Sending the child for a lateral neck radiograph before securing the airway is contraindicated, as the radiology department is not a safe environment for managing complete airway obstruction (Lee, 2003). Repositioning the neck for optimal results could precipitate obstruction.

Complaints include dysphagia and odynophagia; the patient may be leaning forward, drooling saliva and extending the neck. Stridor may be present; hoarseness and loss of vocal power are almost universal.

Since the use of the Hib conjugate vaccine became widespread, the incidence of epiglottitis has diminished by about 90%. However, vaccine failure does occur. In one series, four of the five proved cases since the Hib vaccine became available in the UK involved fully vaccinated children (McEwan et al., 2003). Two of the three affected children in another series had antibody titers in the protective range (Tanner et al., 2002). The incidence of this infection appears to be increasing (Garner and Weston, 2003). Reliance on the vaccine history can lead clinicians to make the wrong diagnosis, with possible life-threatening consequences (Wagle and Jones, 1999). Additionally, epiglottitis caused by streptococci has been reported in Hib-vaccinated children (Midwinter et al., 1999).

Retropharyngeal abscess, which presents with a nearly identical clinical picture, has reportedly increased in incidence. The differential diagnosis also includes foreign body aspiration, vertebral osteomyelitis, lymphoma, and hematoma (especially in hemophiliacs) (Lee et al., 2001).

Epiglottitis in adults is bacteriologically more heterogeneous and has not changed since the beginning of the Hib-vaccination program, according to a Swiss study (Schüpbach et al., 2000). In Sweden, however, the incidence in adults has increased, and the etiology is predominantly *H. influenzae* (Berg et al., 1996). Conservative airway management is generally possible in adults, if facilities for careful monitoring and instant intervention are available.

Epidemiology may change; human anatomy and physiology do not. Microorganisms are marvelously adaptive. A dramatic decrease in disease prevalence could have unanticipated consequences years or decades later. Without the natural boosting of memory cells resulting from occasional encounters with the organism, older individuals may develop increased susceptibility to invasive disease (Rijkers et al., 2003). The wise clinician will not allow life-threatening diseases to drop out of his diagnostic repertoire once preventive measures have rendered them much less common.

Ulceration of the epiglottis is usually caused by squamous cell carcinoma.

Findings in Patients with Obstructive Sleep Apnea

Obstructive sleep apnea is a common but frequently underdiagnosed disorder in middle-aged adults (Kramer et al., 1999). Prevalence has been estimated at between 2% and 5% of otherwise healthy men (White, 1992) or between 0.89% and 37.5% of the general population (Viner et al., 1991). Later estimates of "sleep-disordered breathing" are higher, perhaps owing to an increase in obesity: as high as 9% in women and 24% in men (Parish, 2005). Although associated with a "Pickwickian" habitus (see Chapter 16), obstructive sleep apnea also occurs in nonobese persons (Young et al., 2004). Nocturnal polysomnography is diagnostic, but you must think of the diagnosis to order the test.

A small oropharynx has been noted in patients with the nocturnal obstructive pulmonary disease variant of the sleep apnea syndrome (Shepard, 1987). This correlates perfectly with the cross-sectional area of the upper oropharynx as measured from the computerized axial tomographic scan. In addition to the enlarged uvula mentioned above, other findings include difficulty visualizing

the posterior pharyngeal wall because of the presence of redundant tissue; a short, thick neck; enlarged tonsils; and micrognathia.

The ENT examination will not necessarily suggest the diagnosis; a high index of suspicion is required in patients who report daytime somnolence and nighttime snoring. Reports of "stopping breathing during sleep" and "loud snoring" had a 78% sensitivity and 67% specificity in identifying patients with sleep apnea (Viner et al., 1991). Symptoms develop slowly; patients may not be aware that they are more sleepy than colleagues at work and must be questioned specifically about their falling asleep at inappropriate times. Notably, only 42% of patients referred for overnight oximetry for suspected sleep apnea reported subjective sleepiness. Unspecified "neurologic" complaints were the primary symptoms in 29% and sleep disturbance in only 10% (Martinez et al., 2005).

Comorbid conditions include diabetes, hypertension, myocardial infarction, congestive heart failure, and stroke. Unsuspected obstructive sleep apnea has been found in as many as 83% of patients with resistant hypertension and in 11% to 37% of patients with congestive heart failure. Treatment of the obstructive sleep apnea may benefit these other conditions as well (Young et al., 2004).

Case Reports

An overweight, middle-aged woman who was being worked up for chronic fatigue reported spending increasingly long hours in bed, having progressive difficulty functioning in her job as a nurse, and having a tendency to fall asleep while driving to work. Physical examination and laboratory testing did not suggest a diagnosis to this author. Because the patient lived alone, it was not possible to obtain a history of snoring. She did not wish to invite someone to stay with her but instead placed a tape recorder at her bedside, which revealed loud snoring and long periods of apnea. Polysomnography made the definitive diagnosis, and continuous positive airway pressure brought great improvement.

A physician who suffered greatly from chronic fatigue discovered that it was caused by her *husband's* sleep apnea and was relieved by sleeping in a separate bedroom. The possibility had not occurred to her until her mother-in-law mentioned a television program she had seen about women who were extremely tired because of their husbands' snoring (Korossy, 1998).

A lesson for medical students and attending physicians: The clue to the right diagnosis may not come from a textbook or the medical literature. It is critical to listen to your patients and to keep an open mind.

Larynx

Examination of the larynx is essential in patients complaining of persistent hoarseness. However, indirect laryngoscopy, using a head mirror and a laryngeal mirror, is beyond the scope of this book. If you wish to learn the technique, repeated, supervised practice in the ENT clinic is mandatory. (Otherwise, even if one does glimpse the larynx, one cannot be confident of recognizing the findings.)

A Bouquet of Odors[3]

The usefulness of the doctor's nose as a diagnostic tool was recognized more than 2,000 years ago by Hippocrates and later by the Ayurvedic Sushruta in his work, Samhita (collected works) (Majno, 1975). Many of the odors are on the exhaled breath (Table 13.2); some are due to the skin, sweat, or other body secretions (see Chapter 7 and Tables 13.3 and 13.4).

Acetone

The odor of acetone is the shibboleth of diabetic ketoacidosis. Theoretically, it could also be smelled in starvation ketoacidosis, but such patients probably do not burn enough fat for sufficiently long enough to exhale easily detectable amounts of acetone.

TABLE **13.2** *Other unusual breath odors in diseases and ingestions*

General category	Description	Disease or substance
Sweet	Fruitlike; decomposing apples; acetonelike	Ketoacidosis, lacquer, chloroform, salicylates, phenol
Fishy	Fishy, rancid butter, boiled cabbage	Hypermethioninemia
Other	Burned oregano (or burned hemp)	Marijuana
	Camphor	Naphthalene (mothball or eucalyptus pica)
	Coal gas	Carbon monoxide (odorless but associated with coal gas)
	Garlic	Yellow phosphorus arsenic, tellurium, parathion, malathion
	Metallic	Iodine
	Rotten eggs	Hydrogen sulfide, mercaptans
	Shoe polish	Nitrobenzene
	Disinfectant	Phenol, creosote
	Hydrocarbon	Various hydrocarbons

From Hayden GF. Olfactory diagnosis in medicine. *Postgrad Med.* 1980; 67(April):110–118, with permission.

[3]This is one aspect of what Dr Faith Fitzgerald of California refers to as "extracorporeal diagnosis" (Fitzgerald, 1989).

TABLE **13.3** *Historic use of odors in diagnosis*

Description of odor	Disease
Butcher shop	Yellow fever
Freshly baked brown bread	Typhoid
Freshly plucked feathers	Rubella
Putrid	Scurvy
Rotten straw	"Miliary fever"
Sour or musty bread	Pellagra
Stale beer	Scrofula
Sweetish	Diphtheria

From Hayden GF. Olfactory diagnosis in medicine. *Postgrad Med.* 1980; 67(April):110–118, with permission.

The ketoacidotic diabetic's breath is also described as "fruity," whereas pure acetone (nail polish remover) is not fruity. To me, the ketoacidotic diabetic's breath smells like a chemistry laboratory in which one made longer ketones—the smell is like ripe bananas or like the breath after chewing fruit-flavored chewing gum.

I have seen diabetic ketoacidosis being missed because the clinician would not smell the breath of a patient with poor dental hygiene and, in a second case, because the physician could not smell the acetone through the odors from an unrinsed mouth.

The breath of alcoholic "ketoacidosis" does not smell like fruit because the predominant acid, β-hydroxybutyric, is not actually a keto acid but a hydroxy acid.

Ammonia

Both chronic renal failure and hepatic failure give rise to an ammoniacal odor, but the breath of the two may still be frequently distinguished.

In renal failure, there is a second, fishy component of dimethylamine and trimethylamine (Simenhoff et al., 1977). Additionally, the breath of chronic renal failure often smells uriniferous.

Fetor hepaticus, on the other hand, has a musty component because of mercaptans, dimethyl sulfide, and dimethyldisulfide (Tangerman et al., 1983).

Sewer Breath

The odor of sewage is caused by anaerobes, which may reside in the mouth or anywhere in the respiratory or gastrointestinal tract. Sewer breath may occur in periodontal disease, dental abscess, tonsillar infection, pulmonary abscess, bronchiectasis, gastroparesis, esophageal diverticulum, and intestinal obstruction (in those still capable of belching).

TABLE **13.4** *Other diseases and ingestions associated with unusual odors*

Source of odor	Description of odor	Disease or offending substance
Inborn errors of metabolism		
Urine, sweat, sebum, cerumen	Maple syrup; caramel-like; burnt sugar	Maple syrup urine disease (branched-chain ketonuria)
Urine	Musty	Tyrosinemia
Urine	Like tomcat urine	β-Methylcrotonylglycinuria
Other causes		
Urine	Ammoniacal	Urinary infection with urea-splitting bacteria (e.g., *Proteus* species)
Urine	Medicinal	Penicillin and derivatives
Urine, vomitus	Violets	Turpentine
Skin	Foul, unpleasant	Skin disease with protein breakdown (e.g., pemphigus); hidradenitis suppurativa
Vomitus	Garlic	Arsenic, phosphorus
Stool	Vile, foul	Malabsorption (e.g., cystic fibrosis, celiac disease)
Stool	Rancid	Shigellosis
Vaginal	Foul	Vaginitis; foreign body; sloughing fibroid; malignancy
Vaginal	Semen	Semen (especially in cases of suspected rape)
Pus	Nauseatingly sweet, like rotting apples	Gas gangrene
Pus	Fecal; like overripe Camembert cheese	Proteolytic bacteria

From Burton BK, Nadler HL. Clinical diagnosis of the inborn errors of metabolism in the neonatal period. *Pediatrics.* 1978;61:398–405, and Hayden GF. Olfactory diagnosis in medicine. *Postgrad Med.* 1980;67(April):110–118, with permission.

Alcohol

Because pure ethanol is odorless, it is not possible to smell it on the breath. "Alcohol on the breath" is a misnomer now epidemic in emergency rooms. What one actually smells is the juniper berry in gin, the fusel oil in whiskey, the bouquet of the fermented grape in wine, the hops (a kind of flower) in beer, or the acetaldehyde metabolite of alcohol.

Bitter Almonds

A smell of bitter almonds can be noticed on the breath of a victim of cyanide poisoning. This is due to hydrogen cyanide gas, which is intensely toxic. (Vomitus from such patients must be handled with care, lest medical personnel also be affected by the cyanide.) I have not yet detected this odor on the breath of a patient who has been overtreated with nitroprusside.

Pseudomonas

The characteristic sweet smell noted in cultures of *Pseudomonas* occurs in surface infections and may also be noted on the breath in *some* cases of *Pseudomonas* pneumonia.

Chemical Breath

Pharmaceutical breath refers to breath odors due to the ingestion of pharmaceutical materials, especially in suicide attempts. Paraldehyde, chloral hydrate, ethchlorvynol, and other drugs have characteristic odors. Solvent breath is due to such drugs or to halogenated straight-chain hydrocarbons, chloroform, or carbon tetrachloride (Teschke, 1984). A standard battery of such materials may be kept in the emergency room in capsules or vials that can be opened one at a time until the physician finds the odor that matches the patient's. In this way, the doctor's nose can serve as nature's own gas–liquid chromatograph, which is faster than the one in the chemistry laboratory.

Odors Due to Errors in Metabolism

Abnormal handling of methionine can produce an odor like that of boiled cabbage. An enzymatic block in leucine metabolism may produce an odor like that of sweaty feet or cheese because of the accumulation of isovaleric acid (Liddell, 1976).

The musty smell of new-mown hay is supposedly characteristic of phenylketonuria (PKU). The odor of PKU has also been described as like that of stale, sweaty locker-room towels, or as wolflike or barny (Liddell, 1976). The apocrypha of my student days taught me that the mother of the first child diagnosed as having PKU took the child from pediatrician to pediatrician, complaining that the child smelled "musty, like a mouse." Each dismissed her as unbalanced, until Dr Folling finally agreed to smell the child before laughing at its mother. To his surprise, the child indeed smelled musty, like a mouse. Because of the train of events that he set in motion, the mandatory testing of our day makes it unlikely that anyone will have to smell that particular odor again.

Oasthouse urine disease is thought to be due to methionine malabsorption. An oasthouse in Great Britain is a shed in which hops and malt are stored. A physician might be able to experience the odor by taking a brewery tour, which usually includes the refrigerator where the hops are kept.

For the Attending. It would be a simple matter to set up a teaching lab with concoctions of various materials so that the students could learn to diagnose with their noses, just as radiology residents are taught to identify diagnostic patterns with their eyes. Alas, I do not know of a single school where this is done. The remaining odors in this chapter would not lend themselves to this approach because their specific components are either unknown or are unavailable.

Advances in analytical chemistry, with such wondrous techniques as gas chromatography and mass spectrometry, have to date been applied to testing exhaled breath only in limited clinical contexts, such as exocrine pancreatic insufficiency, small bowel bacterial overgrowth, and other conditions associated with malabsorption. The clinician's nose remains the best detector, currently available, of unusual chemicals on the breath and other effluvia of the human body.

Miscellaneous

The common complaint of "halitosis" may result from a variety of conditions: food remnants; odoriferous foods; periodontal disorders; necrotic soft tissue lesions (e.g., Vincent angina); heavy smoking; or decreased salivary flow due to Sjögren syndrome, antihistamine use, astringent mouthwashes, radiation-induced sialoadenitis, or amphetamine abuse. Dr John Boyles of Ohio always makes it a point to smell the breath himself if a patient has this complaint because the patient's perception is often inaccurate.

Characteristic odors have been claimed for a great variety of diseases (Table 13.3), ranging from the nonspecific such as for chronic sinusitis, through abnormal digestion of fat, to more specific entities such as for streptococcal tonsillitis and diphtheria.

I am reminded of the story that Dr Rene Wegria tells of the golden days at Mount Sinai Hospital in New York City. One morning a great physician arrived for attending rounds, sniffed the air, and said to the resident, "Ah, I can smell that you have a case of typhoid. Let's see that patient first."

"I'm sorry, Professor," said the resident, "we can't see him. That patient was moved upstairs yesterday."

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CHAPTER

14

The Neck

Cervicium dolores butyro aut adipe ursino prefricentur, rigores bubulo sebo, quod strumis prodest cum oleo. Dolorem inflexibilem—opisthotonum vocant—levat urina caprae auribus.... (Pains in the neck should be massaged with butter or bear grease, stiffness with beef wax, which latter is good for scrofula if mixed with oil. The painful rigidity—called opisthotonos—is relieved by pouring nanny-goat urine into the ears....)

—Pliny the Elder, *Natural History*, Book 28, 52:192

Points to Remember:

- The examination of the neck is part of the examination of the cardiovascular system, and of the otolaryngologic, musculoskeletal, and neurologic examinations.
- Check the thyroid for size, consistency, nodularity, and the presence of a bruit.
- The position of the trachea is important for interpreting findings of lung or pleural disease.

Skin findings in the neck are described in Chapter 7, lymph nodes in Chapter 8, arteries in Chapter 18, and neck veins in Chapter 19. The musculoskeletal examination is discussed in Chapter 25, and findings pertaining to the central nervous system are presented in Chapters 9 and 26.

Contour

A webbed neck (pterygium colli or winged neck) with a low posterior hairline (Fig. 14-1) should suggest the diagnosis of Turner syndrome in a patient who is less than 5 ft tall and phenotypically female or Noonan syndrome[1] in either phenotypic men or women (Mendez and Opitz, 1985). A short neck is seen in Klippel–Feil syndrome (Fig. 14-2). A buffalo hump may occur in endogenous or exogenous Cushing syndrome. Patients with obstructive sleep apnea tend to have short, stocky necks (a fact that was first pointed out to me by Dr Ted Woodward of the University of Maryland). Many of these patients wear unusually large-collared shirts (greater than size 17) and still leave them unbuttoned. A lateral swelling in the neck, which appears during the Valsalva maneuver, is probably a laryngocele. This is a benign condition. It may occur bilaterally. The most pronounced example I have ever seen was in the well-known trumpet player John Birks (Dizzy) Gillespie. Glassblowers and patients with chronic obstructive airway disease are also prone to these diverticular outpouchings.

There are also other benign congenital cysts of the neck, related to embryonic structures, which may appear at any time in the patient's life. Branchial cleft cysts are found along the anterior border of the sternocleidomastoid muscle as well as in the pretragal area. Cystic hygromas can appear anywhere on the neck. They are extremely soft and mimic a lipoma but can easily be differentiated by computerized axial tomography (CAT) or magnetic resonance imaging. Thyroglossal duct cysts (*vide infra*) are always in the midline of the neck above or below the hyoid bone. Dermoid cysts are typically in the suprasternal notch. All of these cysts are fairly movable and nontender unless they become infected.

Deep Space Infections

The deep spaces of the neck include the retropharyngeal and submandibular lateral pharyngeal spaces. Infections may track there directly or via lymphatic drainage from the teeth, tonsils, adenoids, sinuses, pharynx, or parotid gland. Such infections are very serious and can be difficult to diagnose. Diabetics and young children are especially susceptible. Symptoms may include fever, deep neck pain, dysphagia, or odynophagia. Physical findings may include trismus, bulging and displacement of the pharyngeal wall, a stiff neck (Swischuk, 1995), and torticollis (Harries, 1997). In advanced cases, there may be dyspnea and stridor.

Thyroid

Inspection

It is often possible to see thyromegaly in cases of thyroiditis, hypothyroid goiter, and hyperthyroidism, especially in the last because weight loss has often thinned out the tissues that normally obscure the borders of the thyroid. A number of goitrous individuals were portrayed in paintings about the time of the Renaissance (14th to 16th century); see, for example, Fig. 14-3. Iodine-deficiency goiter can occur even in iodine-replete regions (Nyenwe and Dagogo-Jack, 2009).

Lingual thyroids can be seen at the base of the tongue.

The Maroni sign is redness of the skin, occasionally with itching, over the anterior neck in the topographic projection of the thyroid gland. It is seen in hyperthyroidism.

Palpation

Most normal thyroid glands are palpable. (Sometimes a Valsalva maneuver will bring a retrosternal goiter up into the neck where it can be felt.)

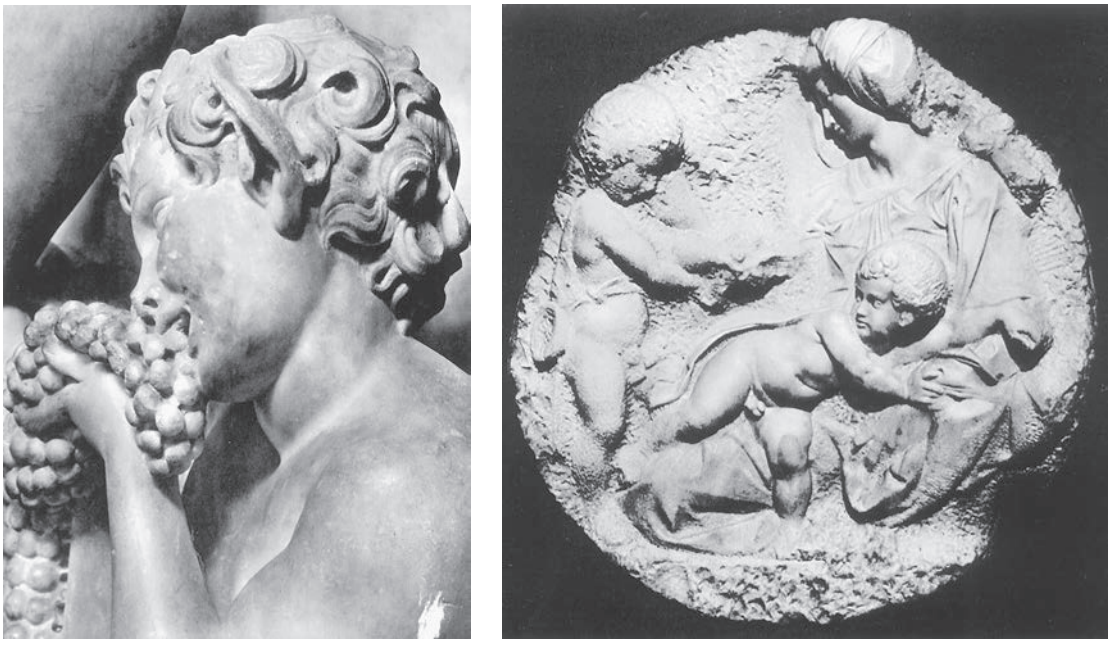
[1] Noonan syndrome has been erroneously referred to as the "male Turner syndrome."

FIGURE 14-1 Low posterior hairline and short, webbed neck in a patient with Turner syndrome. (From Gellis SS, Feingold M. *Atlas of Mental Retardation Syndromes: Visual Diagnosis of Fades and Physical Findings.* U.S. Department of Health, Education, and Welfare; 1968; with permission.)

FIGURE 14-2 Klippel–Feil syndrome. Note the low posterior hairline and short neck displacing the head anteriorly and interiorly. (Drawing of a patient of Dr L. Mermel of Wisconsin.)

A Method

1. Ask the patient to sit in a comfortable position.
2. Hand the patient a large glass of water, saying, "In a moment, I am going to ask you to take some of the water. Hold it in your mouth, and then swallow it when I tell you. That will help me feel your thyroid gland."
3. Walk around to the patient's back, saying, "I won't hurt you," as you place your hands on the patient's neck.
4. Find the Adam's apple by palpation. (The first dozen times you do this you may have to look.) Although this is called the *thyroid cartilage*, the thyroid is actually inferior to this structure. (Thinking that the thyroid is located at the level of the thyroid



A B

FIGURE 14-3 **A:** Satyr (with goiter) Eating Grapes, by Michelangelo. His eyebrows may be thinned laterally. **B:** From the Madonna Taddei by Michelangelo, c. 1504, with permission.

cartilage is the reason that many untutored persons are unable to find the lateral lobes.)

5. Place your right index finger on the right lateral aspect of the thyroid cartilage and place your left index finger on the left lateral aspect. Next, move your two index fingers down to the cricoid cartilage; your index and third fingers are probably now at the level of the middle and upper thirds of the lateral lobes of the thyroid. (This varies with the anatomy of the patient and the examiner.)
6. Have the patient hold some water in his mouth and stare at the ceiling. (This will cause him to extend his neck.)
7. Instruct the patient to swallow. As he does so, the isthmus will ride up under your fingers, in the midline, and will then back down again. The normal isthmus is of a soft consistency, and it will be missed if you press too hard. (Palpation of the thyroid is a learned skill, and you should not be too concerned with what you miss on the first dozen attempts, but if you are consistently unable to feel the isthmus after about 20 palpations, you need to have a more experienced person demonstrate for you on a live patient—see "A Note to the Sophomore.")
8. Now slip your fingers laterally and try to feel under the two sternocleidomastoids. Sometimes, all you will be able to do is get a feeling for the fullness and consistency of those tissues. (In this way, palpation of the lateral lobes of the thyroid is akin to palpation of the ovaries during a pelvic examination. Interpretation of the fullness encountered by your fingers requires considerable experience.)
9. With your fingers at the anterior edges of the sternocleidomastoids, pull them laterally just a little. Have the patient maintain his head in some extension but not so completely that the sternocleidomastoids are tensed. Ask him to swallow again. You should feel the upper parts of the lateral lobes ride up under your fingers and then down again. (Try this on yourself.) During your first dozen palpations of normal glands, you may not feel anything discrete.

An Alternate Method

Approach the patient from the front and feel each lateral lobe in turn by (a) using the fingers of one hand to retract the sternocleidomastoid muscle posteriorly and (b) using the fingers of the other hand to feel the underlying thyroid. Once the lateral lobes are located, the position of the isthmus can be predicted and palpated during swallowing, also with the examiner in front of the patient.

Thyroid Pseudonodules

Other neck lesions in the vicinity of the thyroid can be displaced by underlying structures during deglutition and thus be confused with thyroid nodules. A mass within the thyroid will move with the larynx and thyroid during all three phases of swallowing: an upward movement, a stationary phase, and then a descent (Siminoski, 1994).

Size

Try to estimate the size of the patient's thyroid: "normal," "twice normal," "one-and-a-half times normal," and so on. Large glands may be found in iodine-deficiency states in which the gland attempts to compensate by hypertrophy and hyperplasia even though the patient tends to remain hypometabolic or eumetabolic. More often, however, a diffusely enlarged gland signifies Graves disease (or Plummer–Vinson syndrome, if nodular), and such patients are likely to be hypermetabolic. Enlargement of the thyroid is the most sensitive sign of Graves disease, being found in 81% to 98% of such patients, with the higher sensitivity in younger age groups (Nordyke et al., 1988). The external ocular signs of Graves disease are described in Chapter 10 (see Table 10.2), and additional signs are shown in Chapters 7 and 24. (Note that exophthalmos and pretibial myxedema do not occur in Plummer–Vinson syndrome.)

Small glands are felt in pituitary hypothyroidism and some cases of primary hypothyroidism. *No* gland is felt in athyreotic hypothyroidism.

Nodules

Describe the size and location of any nodules. A single nodule requires further evaluation. Many lumps or nodules in a hypermetabolic person may indicate toxic multinodular goiter (Plummer syndrome), one of the most common forms of hyperthyroidism in the elderly patient.

Consistency

The consistency of the gland should be noted, but its importance should not be overstated until you have done a few dozen examinations, including a few glands of known abnormal consistency.

A firm rubbery gland is felt in some cases of Hashimoto thyroiditis and also in de Quervain thyroiditis. A hard gland is felt in cancer and in Riedel thyroiditis.

The Berry Sign

The Berry sign of malignant thyromegaly is absence of the carotid pulsation (i.e., a malignant tumor tends to encase the carotid so that the pulsation is not detectable). Benign thyromegaly, on the other hand, does not encase the vessel (Clain, 1973).

A Note to the Sophomore

Do not get discouraged. After decades of palpating thyroid glands, I am still learning. The availability of mannequins in my student days would have helped. The only covariable available at that time was the iodine-131 thyroidal uptake scan, which was usually ordered only in hyperthyroidism when the gland was already sufficiently enlarged for even a junior medical student to recognize the condition. At present, the technetium scan, a nonfunctional imager, is available as are thyroidal ultrasounds and CAT scans. These offer an unusual opportunity in physical diagnosis: the use of independent covariables to accelerate the acquisition of skills. However, when comparing your findings with the independent covariable, remember that therapeutic intervention may have changed the size of the thyroid gland since the radionuclide image was recorded, so it is wise to seek the guidance of a faculty member or senior resident. If your institution has a thyroid clinic, you should attend it and practice there.

Auscultation

A systolic bruit over the thyroid gland, if present, may help distinguish hyperthyroidism from other high-output states. False-positive systolic thyroid bruits may be caused by aortic stenosis or aortic sclerosis. These radiating murmurs may be easily misinterpreted by regional specialists who do not routinely examine the whole patient.

The thyroid bruit of hyperthyroidism may be continuous when it is due to the arteriovenous communications that open up inside the highly vascular gland. The prevalence of continuous thyroid bruits (heard best over one of the lateral lobes) is from 20% to 36% in hyperthyroidism (Graf et al., 1947). False-positive continuous thyroid bruits, which are actually venous hums, can be abolished by compressing the ipsilateral jugular veins. The cervical arterial flow murmurs of anemia or fever, in the absence of hyperthyroidism, may also mimic the finding of a thyroid bruit. The differential diagnosis of such a finding, as so often is the case, is elucidated by the company that it keeps.

Dr Susan Ashbee of Alabama once had a patient who had no apparent thyroid disease but had a short, harsh, diamond-shaped murmur heard easily over one lobe of the thyroid. The sound was clearly not a hyperthyroid bruit. The diagnosis of atherosclerotic stenosis of a thyroidal artery was never proved.

A bruit is unusual in Plummer–Vinson syndrome. In Graves hyperthyroidism, a precordial Means–Lerman scratch may be heard (see Chapter 17).

An Historical Interlude: "Dr Jod" and Other Early Thyroidologists

In 1786, Parry saw his first case of hyperthyroidism, but he did not publish it until 1825, 4 years after Coindet published his cases in France (Coindet, 1821). Yet neither of these men has been granted eponymic immortality. Instead the disease is known in the English-speaking world as Graves disease (1835) and in the German-speaking world as von Basedow disease (1840).

Coindet's patients suffered a complication of administering large doses of iodine to susceptible persons. Such iodide-induced hyperthyroidism later came to be called *iodide-Basedow*, which in German is Jod-Basedow, German nouns being capitalized.

Thus, not only has Coindet been deprived of credit for describing hyperthyroidism, but even the variant of hyperthyroidism that he specifically described has been credited by some to Dr Jod—who does not exist!

Special Maneuvers

Thyroglossal Cyst

A Method

1. Grasp the suspected thyroglossal cyst between your thumb and forefinger.
2. Instruct the patient to stick out his tongue as far as possible. For example, say, "Please try to put your tongue on your chin."

Interpretation. If the lump moves under your fingers as the patient extends his tongue, it is a thyroglossal duct cyst. This test is 100% sensitive and pathognomonic.

The Pemberton Sign[2]

A Method

Have the patient hold his arms extended above his head, touching his ears (Fig. 14-4). The test is over after 3 minutes (a negative Pemberton sign) or as soon as a positive sign occurs. A positive sign is a reported sensation of stuffiness, dizziness, congestion, or "funny feeling" in the head. Sometimes the face will become dusky.

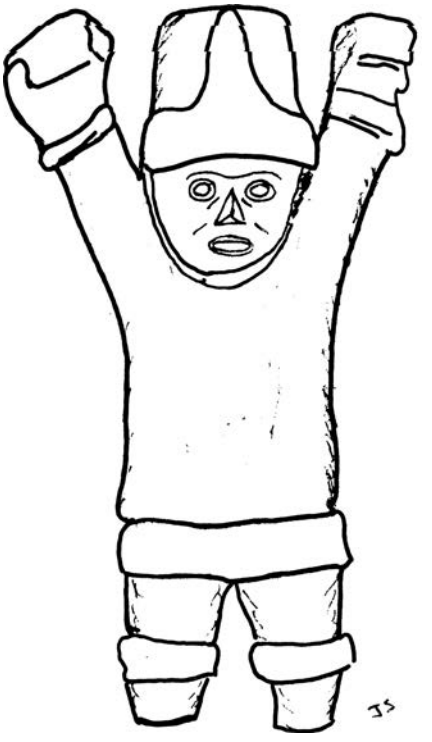


FIGURE 14-4 The Pemberton sign. Drawing of a Huastec statue of the god Quetzlcoatl depicted as an adolescent. The original figurine, which has a red face, is in the National Museum of Anthropology in Mexico City.

Significance

The Pemberton sign occurs when the thoracic inlet rises so that it becomes filled ("plugged"), compressing the jugular veins, as by an enlarged thyroid that extends retrosternally (Basaria and Salvatori, 2004). The Pemberton sign may also be observed with thoracic inlet obstruction (see Chapter 18) or in superior vena cava syndrome (see Chapter 19).

What do you think is the diagnosis for the patient depicted in Fig. 14-4?

Hints. The patient's mouth is open, and the tongue seems to be enlarged. There is some periorbital puffiness, the nose is broad and flat, and the facies are rather dull looking. Prior impairment of linear growth is suggested by the fact that the subject's trunk is longer than his legs. Hypothermia may be inferred from the fact that warm clothing is being worn in the subtropical Mexican Gulf Coast region. Also, the patient is having a little difficulty keeping his arms perfectly apposed to the sides of his head; this might be caused by a myopathy.

Beginning with the puffy face, one could diagnose either nephrotic syndrome or hypothyroidism. Because the face is red (on the original figurine), one might think of the malar flush (not rash) seen in mitral stenosis (see Chapter 17), but the face could be red simply from a positive Pemberton sign. Thyroid enlargement is the first entity one should think of as an explanation for a positive Pemberton sign, and if that sign is positive, nephrotic syndrome and mitral stenosis can be dropped from the list of possibilities. Furthermore,

[2]This is the H.S. Pemberton (1891–1956) of Liverpool cited by Bailey, not J. J. Pemberton, the early 20th-century Mayo Clinic thyroidologist.

there are a number of other findings, such as cold intolerance and macroglossia, which are explained by hypothyroidism but not by mitral stenosis or nephrotic syndrome.

Proceeding further with the diagnosis of hypothyroidism, the impairment of linear growth suggests that the patient has cretinism. The next step is the differential diagnosis of goitrous cretinism.

There are three possibilities:

1. Dietary iodine deficiency. (This would be rather unlikely, given the high iodine content of the usual diet of Gulf Coast fishing tribes.)
2. A dietary goitrogen. (This could be present in a diet containing rutabagas and white turnips, although one would have to postulate that the ingestion was chronic.)
3. One of the six known inherited defects in thyroid hormone synthesis.

I favor the second diagnosis in this patient. Unfortunately, the issue cannot be resolved, owing to our inability to take a dietary history.

A Note on Cretins. The word "cretin" is a shortened version of the French word for Christian, *chretien*. One story is that an early band of Christians fled to the Pyrenees to escape religious persecution. There, they were protected from their pagan neighbors but suffered an iodine-deficient diet. The whole community came to look like cretins, and when one strayed down to a pagan village, he was instantly noticeable as a Christian (*chretien*). A less opprobrious story is set years later in the Alps, where the name *Christian* was applied by Christian villagers to any imbecilic or malformed unfortunate so as to remind the speaker that we are all God's creatures.

Parathyroid Glands

There are no specific physical maneuvers for the diagnosis of hyperparathyroidism. If you find a lump in the thyroid of a hypercalcemic patient, you should not jump to the conclusion that it is an enlarged parathyroid gland.

Analysis

About 90% of parathyroid adenomas and carcinomas are in the lower poles of the thyroid (and so are impalpable). More than 90% are on the posterior surface of the thyroid (and so are impalpable). On the other hand, hyperthyroidism is a more common disease that can be both nodular and, on occasion, hypercalcemic (see "Christian's dictum", Chapter 7).

In the usual nonmalignant case of hyperparathyroidism, the parathyroid glands are not palpable until they have reached individual weights of around 5 g, by which time there should be obvious bone disease.

For the diagnosis of hypoparathyroidism, see the tetanic equivalents discussed in Chapter 26.

Trachea

Inspection

Rarely, one can see a significant tracheal deviation due to a chronic condition such as an aortic aneurysm or, even more rarely, the scarring of old tuberculosis. But in acute situations, tracheal deviation is one of the spectrums of physical findings that permit the correct elucidation of intrapulmonary or intrapleural pathology, and it is therefore discussed in Chapter 16 (as is the determination of tracheal position by palpation).

Palpation

Tracheal Tug: The Oliver Sign

A Method (as Described by the Discoverer)

Place the patient in the erect position and direct him to close his mouth and elevate his chin to the fullest extent, and then grasp the cricoid cartilage between the finger and thumb, and use gentle upward pressure on it, when, if dilatation or aneurysm exists, the pulsation of the aorta will be distinctly felt transmitted through the trachea to the hand. The act of examination will increase laryngeal distress should this accompany the disease (Oliver, 1878).

Semeiophysiology. The aorta normally passes over the left bronchus, which is part of a rigid system that extends up to the trachea. Thus, a bulging outward of the aneurysm depresses the left bronchus with each heartbeat. Each systolic movement is perceived by the examiner's fingers as a tug. Given these anatomic relationships, one can understand the wisdom of Cabot's warning that a tracheal tug felt only during inspiration has no pathologic significance and is frequently present in health. Cabot's second caveat was that the true aneurysmal tug will make the tissues move up and down, not in and out in the manner of the normally transmitted pulsations from the neck vessels.

Other Tracheal Tugs

1. If you press on the thyroid cartilage so as to displace it from the patient's right to his left, you also push the larynx laterally and the left bronchus more firmly against the aorta (see the section on the Oliver sign for a description of the anatomy). If this maneuver produces transverse pulsations of the trachea, the Cardarelli sign is said to be positive. This sign has been erroneously equated with the Oliver sign as the "Oliver–Cardarelli sign."
2. The Campbell sign is a downward motion of the trachea during inspiration. It has been described as a physical finding of chronic airway obstruction (Godfrey et al., 1969). It is best felt by resting the tip of the index finger on the thyroid cartilage. This sign is sometimes said to be present in any patient with respiratory distress, and anesthetists associate it with deep anesthesia or carbon dioxide retention. However, I think the sign is more typical of chronic airway obstruction and is probably produced by the downward pull of the depressed diaphragm (Campbell, 1969).

This sign was subsequently found to correlate very well with both the 1-second forced expiratory volume and the specific airway conductance (Godfrey et al., 1970). Campbell has continued to use this sign for a quarter of a century (Stubbing et al., 1982). Although some workers require the tracheal descent on inspiration to be at least 2½ in. before it is accepted as a sign of pulmonary disease, Campbell and his coworkers describe three different grades whose increasing clinical intensity correlates with a worsening of the 1-second forced expiratory volume.

Percussion

There is no point in percussing the trachea. I have seen it performed only once, as a distraction technique while using the patient's ability to cough to distinguish psychogenic aphonia from laryngeal disease.

A junior medical student on the wards of the Presbyterian University Hospital in Pittsburgh was assigned to an attractive 23-year-old white woman who had experienced an acute onset of aphonia in the absence of prior fever or significant physical findings.

In the course of interviewing the patient (who could only whisper), the student learned that the aphonia had had its acute onset the Monday morning after the patient had experienced the unintended termination of an intense homosexual relationship. This behavior being socially unacceptable at that time, the student was sworn to secrecy. As the patient would not whisper (literally) a word of this to anyone else, the student had no data with which to substantiate his diagnosis of conversion.

At laryngoscopy, no tumors, inflammations, or other lesions could be found, and a neurologic consult was ordered. By now, the patient's hospital bill was almost $90, an incredibly high figure for the time, equivalent to a month's income for an intern.

To make his diagnosis in the absence of the historic data, the student had to resort to determining the posttussive percussion note and recording it in the chart. At first his resident thought that the student was deranged, but the previous week the student (having seen adenoma sebaceum in H.J. Robert's *Difficult Diagnosis*) had been the only person to correctly diagnose a case of tuberous sclerosis in a patient with cryptogenic seizures, so his bizarre physical diagnostic maneuvers were accordingly extended the minimal courtesy of an inquiry.

The student agreed that there was nothing about posttussive percussion notes anywhere in the medical literature and that there could be nothing of any significance in such a percussion note. But, he pointed out, when the patient coughed, she made sounds. That meant that she could control her larynx at times when she made no connection between such motor behavior and the social phenomena of speaking, crying, or making other sounds of emotional distress.

Full credit must be given to the resident, who was willing to listen to the reasoning of a medical student, accept it, and discharge the patient to his own clinic. At follow-up, she was completely asymptomatic.

Auscultation

Tracheal auscultation is helpful in diagnosing tracheal stenosis or other high-grade tracheal obstruction.

This diagnosis is suggested by the presence of a total pattern: a patient with tachypnea; great straining, especially with expiration; use of accessory expiratory muscles; normal tracheal position; the absence of local or lateralizing signs; breath sounds that are disproportionately soft for the amount of apparent distress; and wheezes (actually stridor, see Chapter 16), better heard over the center of the chest than on either side. In combination with this picture, tracheal breath sounds that are more prolonged, more harmonic, more high pitched, more squeaky, and/or more musical than usual make the working diagnosis of tracheal obstruction.

If the patient's face is red, the diagnosis can be confirmed by an air-flow loop analysis and/or direct visualization. If the situation is acute and the patient is beginning to turn blue, assume that the obstruction is at the level of the vocal cords and perform an emergency tracheostomy.

Tracheal obstruction and stridor heard when the neck flexed, but not when the neck is extended, should suggest a congenital cardiovascular ring anomaly compressing the trachea and the esophagus (see Chapter 18). About 37% of such patients have dysphagia, which is aggravated under such circumstances, leading someone to christen this syndrome with the macabre title *dysphagia lusoria* or "dysphagia from a joke," the congenital anomaly being thought of as a joke of nature (a more misanthropic attribution than an error of nature).

Special Maneuvers: The Kocher Test[3]

Compress the lateral lobes of the thyroid. If this produces stridor audible without the stethoscope, the patient has either carcinoma of the thyroid, a goiter, or thyroiditis (Clain, 1973).

Self-test

If you are reading this work in sequence and you have followed the advice of looking up words and phrases with which you are not familiar, it will not surprise you to learn that relapsing polychondritis can affect the trachea, producing signs and symptoms.

Salivary Glands

Location

The salivary glands include the parotid glands, the submaxillary glands, the sublingual glands, and numerous individual cells located in the buccal mucosa, the palate, and other mucous membranes of the oral pharynx.

The parotid glands, which are not normally palpable even in the elderly, are located over the ascending ramus of the mandible anterior to the ear. They extend behind the ear, enclosed in a capsule attached to the styloid process and the angle of the mandible.

The submaxillary glands are found medial to the horizontal ramus of the mandible and are difficult to palpate in the young but easily palpable in older patients. Bimanual palpation between the floor of the mouth and upper external neck is mandatory for a thorough examination. These glands are walnutlike in size and shape.

[3] Kocher was the Swiss physician who won the Nobel Prize for Medicine and Physiology in 1900 for his work on the thyroid gland. He was not the only Nobelist who was also a physical diagnostician. An Austrian, Robert Barany, won the same prize in 1914 for research on the physiology of the vestibular system but is better known to us as the inventor of caloric testing (see Chapter 26). Barany was the last clinician to win the Nobel Prize and also to have a physical maneuver named after him. Philip Hench, who was cowinner of the Prize for his work on adrenal corticosteroids, had a test named jointly for him (for mercury in the saliva) and a clinical phenomenon named solely for him (for the amelioration of rheumatoid arthritis during obstructive jaundice), but I have not heard of a sign or a maneuver named for him.

Swellings

All salivary glands, both major and minor, are subject to the same pathology. Any gland can become infected or develop a wide array of tumors. All are subject to obstruction or the formation of calculi and cysts. In general, tumors are more common in the parotids, and calculi are more common in the submaxillary glands.

Unilateral Swelling

A painful unilateral swelling may be due to bacterial parotitis, commonly from *Staphylococcus* or *Streptococcus viridans* infections, or from an obstruction in the Stensen or Wharton duct (Federman, 1962). Obstruction is usually caused by a calculus, but in one case, the Wharton duct was obstructed by a blade of grass on which a soldier had been sucking (Talman, 1963). Acute parotitis without obstruction may occur, usually in elderly patients who are dehydrated.

Obstructions typically cause painful unilateral swelling after the patient has eaten. Such obstructions can sometimes be diagnosed by inspection or palpation of the orifices (see Chapter 13); the stone may be seen or pus may be noted (unrelieved obstruction frequently results in infection). Also, compare the amount of saliva on the two sides; the obstructed side will be much drier. Giving a patient a slice of lemon to suck on will make the difference in wetness much more obvious, and it may also quickly produce swelling. One caveat is to avoid performing the lemon test on patients whose saliva may be infectious. If the tongue is held up, the saliva may shoot out of the mouth, traveling a foot or more.

Parotid tumors tend to be unilateral and are not usually painful. They are nonmovable. The overlying skin is unattached, except in malignancy. If a parotid tumor has caused a facial paralysis, it is malignant. Soft masses in the tail of the parotid are typically Warthin tumors (papillary cystadenoma lymphomatosum), which are benign. Tumors that are constantly painful without signs of infection or obstruction may be adenoid cystic carcinomas (cylindroma). A swelling in the parotid region may be due to actinomycosis involving the skin and soft tissue (but not the parotid gland). Edema over the parotid may be seen in infections of the deep spaces of the neck.

Bilateral Swelling

Bilateral infectious parotitis is most commonly due to mumps but may be seen with other viruses such as choriomeningitis virus.

Enlargement of the salivary glands due to infiltration by CD8 lymphocytes is seen in both adult and pediatric human immunodeficiency virus (HIV) infections. Occasionally, these glands develop benign lymphoepithelial cysts that may cause pain. The cause of the HIV-related change is not known; it seems to be associated with the slow progression of the disease (Greenspan and Greenspan, 1996).

Drug reactions can cause bilateral parotid swelling, either with or without pain. Such drugs include, but are not limited to, iodide, lead, propylthiouracil, mercury, isoproterenol, sulfonamides, and oxyphenbutazone.

Leukemic infiltrates and lymphomas, both Hodgkin's and others, may involve the salivary glands bilaterally.

Mikulicz disease, which is synonymous with Sjögren syndrome, may cause bilateral enlargement of the salivary glands. This may be accompanied by xerostomia (see Chapter 13). Mikulicz syndrome, which consists of the signs and symptoms of Mikulicz disease occurring as a consequence of some disease other than Sjögren, may be associated with tuberculosis, Waldenström macroglobulinemia, systemic lupus erythematosus, or sarcoidosis. With the last disease, one may have Heerfordt syndrome if there is uveitis or if cranial nerve VII is involved. A collection of metabolic diseases, which may overlap to some degree, may also cause painless bilateral swelling. These include cirrhosis, pellagra, malnutrition, kwashiorkor, bulimarexia (Harris, 1983), vitamin A deficiency, excess starch ingestion (Silverman and Perkins, 1966), diabetes mellitus, post-starvation refeeding, obesity, and perhaps thyrotoxicosis. Others have reported bilateral painless swelling due to periodic sialorrhea, pregnancy, lactation, stress, allergy, or heredity.

There is increasing evidence in the literature for a parotid abnormality associated with alcoholism, with or without liver disease (Barnett and Wilson, 1986). Bilateral painless swelling of the submaxillary glands is also seen in sober male veterans over the age of 50. Some skeptics have challenged the veracity of the negative alcohol history claimed for these patients, but this phenomenon turns out to have been noted years ago by others (Kelemen and Montgomery, 1958).

Gustatory Sweating

Frey syndrome, also called *auriculotemporal syndrome* or *gustatory sweating*, occurs in patients who have had parotid surgery. When the patient is eating, the ipsilateral forehead becomes drenched with sweat, apparently because some remaining salivary nerve fibers connect with autonomic efferents.

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CHAPTER

15

The Breast

If a woman who is not with child, nor has brought forth, has milk, her menses are obstructed.

—APHORISMS, *HIPPOCRATIC WRITINGS*

POINTS TO REMEMBER:

- Breast cancer is the most frequently diagnosed cancer in American women, aside from skin cancer, and is the second leading cause of cancer death in women. The incidence has increased more than 50% since 1950, and younger women are affected more often.
- Most palpable lumps are benign.
- Galactorrhea can result either from intramammary or neurohumoral mechanisms. Evaluate the hypothalamic–pituitary axis if abnormal menses are associated.
- Gynecomastia is a common finding. Symptoms or signs that point to a need for investigation include pain, rapid breast enlargement, or presence of a mass. When in doubt, do a mammogram!

The examination of the breasts is an extremely important part of the physical examination in women, largely because of concerns about breast cancer, the most commonly diagnosed cancer and the second leading cause of cancer death among women in the US. The annual incidence of breast cancer increased by 52% during 1950 to 1990, while the death rate from breast cancer increased by 4% during the same period (CDC, 1994). The increase in incidence was about 40% between 1973 and 1998 (Howe et al., 2001; Kufe et al., 2003). Moreover, the disease occurs in younger women, who are likely to have more aggressive tumors (Sundquist et al., 2002). The interpretation of trends is complicated by the fact that in 2003 ductal carcinoma in situ (DCIS) was removed from the overall incidence (A. Lanfranchi, *personal communication*, 2009). DCIS had increased more than threefold, from 3.8 per 100,000 to 12.1 in 100,000 in women under age 50 between 1975 and 2005 (National Cancer Institute).

Lumps are not uncommon. As many as 89% of postmenopausal women have evidence of benign breast disease at autopsy (Grady et al., 1988).

The examination should also not be neglected in men, although cancer of the male breast is rare.

History: Risk Factors for Breast Cancer

Various historic factors influence the prior probability of breast cancer. Certain risk factors that have received a great deal of publicity (hormone use, alcohol consumption, obesity, and nulliparity) present a fairly modest relative risk (RR) for breast cancer (RR < 2). A history of breast cancer in a first-degree relative confers an RR of 2.1 or more, and a positive test for a breast cancer susceptibility gene (BRCA), an RR greater than 4. Women with BRCA1 mutations are estimated to have a 65% risk of developing breast cancer by age 70 (American Cancer Society, 2008). Patients with goiters owing to iodine deficiency have a three times greater incidence of breast cancer. For this and other reasons, "subclinical" iodine deficiency manifested by a urinary iodine concentration less than 50 μg per L is thought by some to be a risk factor both for breast cancer and fibrocystic disease (Miller, 2006).

The effect of ionizing radiation depends upon the dose. High doses are harmful, but low doses appear to be beneficial through nonspecific stimulation of biologic repair mechanisms (hormesis). In the Canadian fluoroscopy study, the RR of breast cancer at 10 to 19 cGy (1 cGy = 1 rad) cumulative exposure was 0.66 compared with controls; the RR was 0.85 at 20 to 29 cGy, and it was not significantly higher at 30 to 69 cGy. Beginning between 1930 and 1952 and being followed for up to 50 years, this study involved 31,710 Canadian women examined and treated for tuberculosis with X-ray doses to the chest (Miller et al., 1989). Mammography routines in the 1990s were claimed to deliver as little as 0.2 cGy, apparently for each pair of views of each breast, totaling 0.4 cGy per total examination. Thus, if a woman of 50 began in 1990 to have annual mammograms until age 75, the cumulative dose would be 10 cGy, which is within the optimum hormetic dose range. Therefore, avoiding mammography because of the radiation is not justified (Kauffman, 2003).

Early childbearing has a protective effect. One study estimated that "women having their first child when aged under 18 years have only about one third the breast cancer risk of those whose first birth is delayed until the age of 35 years or more" (MacMahon et al., 1970).

Breast cancer is known to be hormonally sensitive, yet the role of various risk factors involving estrogens—hormonal contraceptives and estrogen-replacement therapy—has been intensely controversial. Evaluation of these factors is confounded by the undisputed enhanced risk of early menarche and late menopause and the likely prolonged use of hormonal contraceptives before the first full-term pregnancy (Fentiman, 2002). In one major textbook, the RRs are listed in the text, but not in a table, as being 1.24 for oral contraceptives and 1.26 for hormone replacement therapy (Bland and Copeland, 2004).

Oral contraceptives have been classified as a class I carcinogen (Cogliano et al., 2005), but conflicting information has been published on the National Cancer Institute's website (Lanfranchi, 2008).

It is noteworthy that breast cancer incidence (i.e., the incidence of cancers that had grown large enough to be detectable) diminished by 3.5% per year between 2001 and 2004, particularly in women aged 50 to 69; this has been attributed to the rapid decrease in the

use of hormone replacement therapy beginning in 2002 (American Cancer Society, 2008).

The hormones of pregnancy have a far greater proliferative effect on the breast than exogenous hormone treatment. As the first pregnancy comes to term, however, the milk glands mature, accounting for the protective effect. If this process is interrupted before 32 weeks, by premature delivery or abortion, the woman is left with a large increase in the number of immature cells that are vulnerable to carcinogenic factors. Spontaneous abortion in the first trimester appears to have no significant effect on breast cancer incidence. Women often report that they "did not feel pregnant"; the pregnancy fails owing to inability of the fetal-placental unit to produce enough hormones to sustain the pregnancy or to stimulate growth in the mother's breasts (Lanfranchi, 2008).

At least 38 epidemiologic studies exploring an independent link between induced abortion and breast cancer have been published, 29 of which report risk elevations. There have been two metaanalyses coming to conflicting conclusions (Brind et al., 1996; Collaborative Group on Hormonal Factors in Breast Cancer, 2004).

Brind et al. estimated that in 1996 an excess 5,000 cases of breast cancer were attributable to abortion and that the annual excess would increase by 500 cases each year. Reviewing a 2001 report, Brind stated that abortion could explain the entire rise in breast cancer since the mid-1980s and that the absolute numbers of increased cases fall within the range of the numbers predicted in the 1996 metaanalysis (Malec, 2003). The overall odds ratio was found in that analysis to be 1.3 (95% CI 1.2 to 1.4) for any induced abortion (Brind et al., 1996).

The increasing incidence of breast cancer in eight European countries since 1971 was found to correlate best with induced abortion, of the seven reproductive risk factors. Fertility was also a useful predictor. Using data up to 1997, the model gave accurate predictions through 2004 (Carroll, 2007).

Although an increased risk on the order of 30% is relatively modest in an epidemiologic sense, the absolute number of cases in the population would be large because breast cancer is so common. Moreover, the risk in certain subgroups appears to be quite significant. In one study, women without positive family histories who had obtained abortions before age 18 and gestation between 9 and 24 weeks had an RR of 9.0 (Daling et al., 1994). The study also included 12 cases with a family history of breast cancer in which the women obtained abortions before age 18. No controls free of breast cancer in the study had this history. All of the cases developed breast cancer before age 45. For this group, the study reported an RR of infinity.

Currently, many influential groups deny any possible connection between induced abortions and breast cancer. For some women, however, the existing evidence could influence their decisions, and some courts have ruled that the potential risk should be included in obtaining informed consent. Additionally, physicians at some point could be held liable if they are not sufficiently vigilant in monitoring patients who may be at risk or in advising patients of the risk. Aside from an independent effect of abortion on breast cancer risk, abortion in a nulliparous woman certainly increases the duration of the "susceptibility window"—the length of time between puberty and the first full-term pregnancy— during which the breasts are especially vulnerable to carcinogens.

In summary, the history of risk factors for breast cancer should include the use of hormones and a complete pregnancy history, including the patient's age when she became pregnant and the outcome of each pregnancy, including the length of gestation.

The absence of risk factors is never decisive. Biopsies must be performed on all suspicious lesions. If the patient herself presents with a lump, ask how long it has been present, whether there is associated cyclic tenderness, and whether it waxes or wanes with the menstrual cycle. A nodule that has been unchanged for more than a year or one that shows cyclic changes is likely to be benign (Grady et al., 1988).

Draping the Female Patient

Adequate exposure, of course, is essential, but many women will be uncomfortable if their modesty is not protected. Gynecologists often have the patient wear a gown that opens in the front and then place a sheet on the patient's lap. The gown can be opened to examine the breasts, then closed to cover them during the rest of the examination. The sheet can be used to cover the pubic area while the abdomen is inspected and then be raised to cover the abdomen when the genitalia are examined. From the viewpoint of the internist or general physician, it is inconvenient to have the gown open in the front for purposes of the general physical examination, especially the chest examination. (It cannot easily be raised because the patient will be sitting on it.) Therefore, some prefer to have the opening in the back. To examine the breasts and auscult the heart, the physician can either lower the gown from the shoulders (when the patient is sitting) or raise it (when the patient is supine), keeping the lower part of the body covered with a sheet. One solution is to use a short gown that opens in front, plus a sheet.

In these litigious days, it is advisable to have a female attendant present during the breast examination, especially if the physician is a man.

Inspection

A Method

Patients should be examined both seated and supine. While the patient is seated, disrobed to the waist, the breasts should be inspected. Look for asymmetry (a certain amount is normal); a change in contour or a visible swelling; retraction, edema, erythema, or dimpling of the skin; or an increased prominence of the venous pattern. Skin retraction is usually a sign of carcinoma, although it can result from fat necrosis. If a tumor blocks the lymphatic drainage, an area of lymphedema, which often looks like an orange peel (*peau d'orange*, pronounced poe-der-awnj), may result. Local areas of redness indicate underlying inflammation; this can occur in inflammatory carcinoma or infection.

Changes induced by pregnancy are summarized in Table 22.2.

Traditionally, the inspection of the breasts has included the following maneuvers described by Haagensen: First, the patient's arms should be in her lap so that the pectoral muscles are relaxed.

Second, she should be asked to press her hands firmly on her hips to contract the pectoral muscles. Third, she should raise her arms above her head. If the patient has pendulous breasts, it may also be helpful to have her stand and lean forward, supported by the back of a chair or the examiner's hands.

These time-honored but time-consuming maneuvers seldom reveal changes suggesting a cancer in patients not having a palpable lump and are often deleted from a screening examination.

Nipples

Particular attention should be paid to the nipples. An inverted nipple, unless long-standing, suggests carcinoma. Normally, an inverted nipple can be everted to its correct anatomic position; inability to do so mandates a biopsy unless the patient recognizes the inversion as a congenital defect (Bland and Love, 1992). Scaling, crusting, or ulceration of the nipple suggests Paget disease of the breast, a malignant condition in which a lump may not be palpable. Paget disease of the breast does occur in men also. The differential diagnosis includes malignant melanoma and Bowen disease (intraepithelial squamous cell carcinoma) (Desai et al., 1996). Scaling of the areola only is probably eczema, but if scaling involving the nipple does not go away after using a corticosteroid cream for about 10 days, biopsy is needed (A. Lanfranchi, *personal communication*, 2009).

Supernumerary Nipples

Supernumerary nipples or breasts (polythelia and polymastia) are rather frequent minor errors in development, having an incidence varying from 0.22% to 2.5%. They are more common in men and in blacks. They are located in the milk line on the thorax and abdomen, most commonly just below the normal breast. They may be mistaken for a pigmented mole, but close inspection generally reveals a miniature nipple and areola.

Although supernumerary nipples have been considered clues to the diagnosis of congenital heart disease, they are of very low sensitivity and diagnosticity. Other associations have been suggested (Pellegrini and Wagner, 1983) but not proved. In fact, the only statistically significant associations are with duplicate renal arteries and renal adenocarcinomas (Goedert et al., 1981). However, black infants with supernumerary nipples do not need to be investigated for renal anomalies (Robertson et al., 1986).

Absent Nipples

Absence of a nipple on only one side with an absent pectoralis major on the same side, sometimes in association with brachydactyly, or a small hand, is known as *Poland syndrome*. In children, it has been associated with leukemia (Hicsonmez and Ozsoylu, 1982), but it is also seen in adults with prolapsed mitral valves and no other associated abnormality.

Bilateral absence of nipples is a completely different syndrome. Sometimes it is associated with other congenital abnormalities.

Adrenocortical Insufficiency

I only examine the nipples of men intentionally when I am trying to make the diagnosis of chronic primary adrenocortical insufficiency. Because adrenocorticotropic hormone and its precursors have the melanocyte-stimulating hormone peptide sequence, patients with primary adrenocortical insufficiency may eventually develop pigmentation of scars and nipples. However, the absence of pigmentation (light-pink nipples) is far more helpful in excluding the diagnosis than its presence is for establishing it. Just as the Indonesian connection altered the Dutch gene pool sufficiently to make pigmentation misleading (as Snapper and Kahn [1967] noted), the blue-eyed blond gene pool in the US is so mixed with DNA from Mediterranean and other swarthy people that pigmentation in any individual is worse than useless. Especially in black Americans, the "classic" skin signs of chronic primary adrenocortical insufficiency (including dark palms, dark elbows, and mucosal blue spots) are frequently encountered in those whose hypothalamic–pituitary–adrenocortical axes are paragons of adequate homeostasis.

Palpation

A Method

1. If the patient has large breasts, some advise bimanual palpation while she is still sitting up, though others think this is not a good method. Support the breast from below with one hand and gently compress it from above with the other. It may be helpful to roll the tissue back and forth between the two hands.
2. In all patients, palpation is performed with the patient supine, with the arm on the side to be examined placed behind the head. Other methods of getting the breast to lie squarely on the chest wall are to prop up the shoulder and upper back on a pillow or to hold the breast on the chest wall with one hand while examining it with the other (Scanlon, 1987). A patient with large breasts may be asked to turn about 30 degrees to one side. The key is to press the breast tissue against something hard.
3. An orderly examination is necessary to ensure that no areas are missed. Some physicians use a pattern resembling the spokes of a wheel, starting with the tail of the breast in the axilla and then moving from the outer boundary of the breast toward the nipple until the entire circumference has been covered. Some use a spiral pattern, moving from the periareolar area to the periphery of the breast (Scanlon, 1987).
4. Use a gentle, rolling motion, pressing the breast tissue between your fingertips and the chest wall. Very small lumps are most easily felt with the pads of the fingers, but lumps larger than about 1 cm can be evaluated by placing your fingers on either side of the mass and pressing against the chest wall. The texture of the tissue around the lump is best appreciated by passing the fingers over it lightly (Scanlon, 1987).
5. While performing the examination, explain to the patient what you are doing and encourage her to do the examination herself once a month, preferably at the onset of her menstrual period or 1 to 2 days later. Remember that the word "doctor" comes from the Latin *docere*, which means to teach. Point out that 85% of solid lumps turn out to be benign (Mahoney and Csima, 1982). After fear, the biggest impediment to breast self-examination is that patients have not been taught how to do it. Be sure to explain that the normal breast may have lumps and bumps that enlarge and subside with the menstrual cycle. Frequent examinations,

preferably starting at a young age, are needed so that the patient will learn to recognize what is normal.

The patient could perform the examination lying down or while in the bath. Many breast lesions are discovered accidentally while bathing, and it has been suggested that a mass can be more easily detected under a slippery film of soap. Dr Angela Lanfranchi uses ultrasound gel or Ky jelly, finding that liquid soap or lotion tends to dry out.

Patients who reside in Canada may be able to obtain a simple device called a *Sensor Pad*, consisting of two soft sheets of plastic with silicone inside, which purportedly allows women to detect lumps, even the size of a grain of salt, in their breasts. The device was approved in Canada in less than 60 days, but after 9 years and after spending $2 million, the inventor was unable to obtain approval from the U.S. Food and Drug Administration (Samp, 1994). A literature search revealed no information about the sensitivity and specificity of the device for finding cancers.

6. If the patient has come to you with a complaint of a mass in the breast, be sure to have her point it out to you, after you have completed your examination. It is not unheard of for the patient to find a mass that the doctor has missed. Even if a patient cannot feel a mass herself, Dr Lanfranchi will do a biopsy if an area that the patient thinks "feels different" persists for 3 months. The biopsy is generally abnormal, usually showing benign proliferative disease, but occasionally a cancer.
7. Be sure to check the lymph nodes that drain the breast: axillary, supraclavicular, and infraclavicular (see Chapter 8).
8. Finally, palpate the nipple for a mass or induration.

Findings

Normal Breast Tissue

The normal consistency of breast tissue is quite variable from one individual to another and at different times in the menstrual cycle. "Like a bean bag" is one good description that patients readily understand. The milk glands feel like radiating strands of firm tissue having a variable degree of granularity. Swelling, tenderness, and greater prominence of the glandular elements may be noted in the week before and during the menses. "Thickening" occurs most commonly in the upper outer quadrant of the breasts, an area with more glandular tissue than other areas. The normal inframammary ridge, a firm transverse ridge of tissue along the lower edge of the breast, most prominent in large breasts, should not be confused with a tumor. Likewise, there is a cavity under the nipple, the edge of which may feel like a lump. Another confusing finding may be rib cartilage joining bone. Checking for symmetry may help ascertain what is normal in an individual patient.

Describing the Dimensions of Breast Nodules

If a nodule is found, you should describe the following dimensions:

1. *Size*. Plastic calipers are suggested for making measurements, which, of course, should be recorded in the patient's chart.
2. *Location*. The breast may be *divided* into four quadrants with the axes passing through the nipple, but radial coordinates are more precise. Describe the location of the mass by its distance from the nipple and its position in terms of the hours on a clock. Sketch a diagram in the patient's record.
3. *Tenderness*
4. *Consistency or firmness*
5. *Shape*. Is the mass regular, irregular, discoid, round, or nodular?
6. *Relation to surrounding tissues*. Is it freely mobile, or is it fixed to the fascia or the skin? The maneuvers described by Haagensen may be helpful. To demonstrate "tethering" of the skin above a carcinoma, elevate the breast gently with the hand and look for an area of dimpling. Is the border between the lump and the normal tissue distinct or difficult to discern?

Characteristics of Benign and Malignant Lumps

Benign breast lumps are usually multiple, bilateral, generally uniform, and symmetrically distributed. The sensation on palpation is generally like sliding one's fingers over a mass of peas or grapes. The consistency of the nodules may vary from firm and rubbery to fluctuant. Although clinicians may refer to this condition as "fibrocystic disease," the latter is a pathologic diagnosis; it is preferable to use the term "lumpy breasts." If one mass in a diffusely nodular breast is clearly larger or firmer than the rest, it is called a "dominant mass" and a biopsy should be performed on it (Grady et al., 1988). If the patient is not at high risk, Dr Lanfranchi will observe a prominent area for three menstrual cycles before doing a biopsy; 85% resolve. A trial of iodine supplementation while the patient is under careful observation may be worthwhile, as a 70% success rate in treating fibrocystic disease has been reported (Miller, 2006).

Tenderness is often a feature of benign lesions, but the presence of tenderness does not rule out a malignancy.

Carcinomas often feel hard and may have indistinct boundaries. A mass that is fixed to surrounding tissues is likely to be cancerous. However, four of ten cancers feel well circumscribed, four of ten feel soft or cystic, and six of ten are freely movable (Mushlin, 1985).

Interobserver Variability

There can be considerable interobserver variability in the individual findings of the breast examination. In a study of 242 women presenting with a complaint of a lump in the breast, two observers disagreed about the consistency of the mass in 33%, about the presence of a clear boundary in 35%, and about the presence of homolateral axillary nodes in 45% (Yorkshire Breast Cancer Group, 1977).

There is also considerable variability in the synthesis of the findings. A study in which four surgeons specializing in breast disease each examined 100 patients (41 of whom had been admitted for a breast biopsy and the remainder for other operations) showed that experts often differed in their opinions, especially about patients who did not have cancer. The examiners noted a mass in 32 to 42 cases, but in only 16 patients did all four surgeons agree as to whether a biopsy should be performed. All four surgeons recommended a biopsy in 11 of the 15 patients who turned out to have a malignancy (Boyd et al., 1981).

Fortunately, the advent of mammography and fine-needle aspiration has made it far less traumatic to investigate all doubtful lumps, without immediately resorting to the "when in doubt, cut it out" method of yesteryear.

Sensitivity of the Physical Examination

With silicone models, the sensitivity of the physical examination for detecting lumps is 17% to 83%, increasing with greater duration of search but *not* with level of experience (Fletcher et al., 1985).

The sensitivity of breast palpation for detecting cancer has variously been reported as 24% (Hicks et al., 1979), 38% (Moskowitz, 1983), and 62% (Egan et al., 1977). Many early lesions are missed. Thus, it is now widely recommended that mammography be used to supplement the physical examination as a screening technique because it has a higher sensitivity (62%, 72%, and 87%, respectively) in the studies cited above. However, the physical examination should not be omitted. In 7% of the cancers detected by physical examination, findings on mammography were benign, and 25% of the cancers were diagnosed between screenings because of self-discovered abnormalities (Hicks et al., 1979).

Mammography as a Screening Test

Universal mammographic examinations are being recommended at younger ages and with greater frequency, sometimes by one vote after a highly contentious committee debate (Kauffman, 2006). As with all screening tests, false positives occur, subjecting the patient to the anxiety, cost, and pain of further workup.

Self-test. Given that the sensitivity of mammography is 87% and the specificity 93%, calculate the predictive value of a positive test and the predictive value of a negative test in a population of American women aged 40 to 50 in which the prevalence of breast cancer is 0.8% (Appendix 15.1). Of course, as with all screening tests, the predictive value of a positive test is much greater in a population with a higher prevalence of disease.

Some believe that it is astonishing that a screening test this poor has achieved such widespread acceptance and has obtained insurance coverage. The rationale depends critically on the belief in the efficacy of early detection and on the fear of malpractice liability for delayed diagnosis. Mammography detects lesions about 1 to 2 years earlier, on average, than they would have been found by palpation. By the time a tumor is palpable, it has been growing for a mean time of 8 years. The question is whether early therapy increases life expectancy or only the time during which the patient is worried about the cancer. The answer depends on the efficacy of treatment and needs to take into account the all-cause mortality, including heart disease or hematologic conditions caused by radiation or chemotherapy, not just death from the cancer.

Better screening tests would be highly desirable. A number of other imaging methods exist, but information about their sensitivity and specificity is not readily available at this time.

Auscultation

A mammary souffle may be heard over the engorged breasts of a pregnant woman. This may be either systolic or continuous. Its origin may be either arterial or venous (Perloff, 1980). The systolic form is easily distinguished, by location, from the systolic pulmonic flow murmur that is heard in about 50% of pregnant women. This, in turn, is distinguished from hemodynamically significant pulmonic stenosis by attending to the second heart sound (S2) as described in Chapter 17.

Discharge from the Breast

A discharge from the nipples is very common in premenopausal women. In an ambulatory population, it was found in 13% of nulligravida and 22% of parous women between the ages of 16 and 50. Prolonged lactation was the most common cause (29% of cases). No definite cause was found in 43% of 586 cases (Newman et al., 1983). Nipple discharge alone is a rare presenting symptom for carcinoma, occurring in less than 3% of patients (Chaudary et al., 1982). Conversely, of patients with a nipple discharge, 5.9% (Chaudary et al., 1982) to 13.3% (Leis et al., 1988) were found to have carcinoma.

Serous or Bloody Discharge

A serous or bloody discharge from the nipple can result from a wide variety of causes (Atkins and Wolff 1964; Barnes, 1966). Benign causes include fibrocystic disease, duct papilloma, papillary cystadenoma, chronic infective mastitis, duct ectasia, hematoma, and breast abscess. Malignant causes include DCIS, Paget disease of the breast, and neurosarcoma.

It is useful to test the discharge for occult blood. In a study of patients undergoing microdochectomy for a discharge that could be localized to a single duct, all 16 patients with an occult cancer had a positive test for occult blood. Of the 268 benign lesions, 69 produced a discharge that was negative for blood and 199 produced a discharge that was positive. The discharge was not tested in eight cases (Chaudary et al., 1982). In an earlier study, all 27 cases that tested negative for blood had a benign cause (Atkins and Wolff, 1964).

What is the sensitivity of occult blood for carcinoma in patients presenting with only a discharge? What is the predictive value of a negative test? What was the specificity (in the study of 268 benign lesions)? What does this say about observation versus immediate surgery? Write your answers down before looking at Appendix 15.2.

Notwithstanding the answer to the above question, it is not prudent to withhold a simple test (a biopsy) on the basis of a few small studies. Breast surgeon Lanfranchi would biopsy patients with a discharge having any of the following pathologic features: spontaneous (noticed on bra or nightgown); involves one breast or one duct; serous or bloody in character; or associated with a mass. If all these criteria are fulfilled, the risk of cancer is about 10%. Features indicating a benign cause are occurrence only when the doctor squeezes (some discharge can be expressed in 60% of women); bilateral; involves multiple ducts; colored; or not associated with a mass (A. Lanfranchi, *personal communication*, 2009).

Milky Discharges (Galactorrhea)

Abnormal milky discharge may occur in either sex at any age, though it is quite unusual in men and generally occurs in the context of a feminizing state (Wilson, 1994).

The Talmud describes a man who nursed his baby after his wife's untimely death, likely the first reported case of male galactorrhea (Melmed and Kleinberg, 2007).

Both intramammary and neurohumoral mechanisms must be considered. In theory, local etiologies should cause a unilateral discharge, whereas neurohumoral mechanisms should cause a bilateral one. However, the rule has many exceptions. Cystic disease may be bilateral, and one breast may initially be more responsive than the other to hormonal stimulation.

Mechanical stimulation has long been known to be a way of inducing lactation. Eliciting the history may require some tact as well as knowledge of the possibility. Lactation may also follow trauma or surgery to the breast or chest wall or an outbreak of herpes zoster, presumably through stimulation of the thoracic nerves.

Attenuation of the hypothalamic–pituitary suppression of prolactin production is another mechanism, which may result from postpartum pituitary necrosis (Sheehan syndrome) or Chiari–Frommel syndrome. Additional causes of lactation include other pituitary disorders, such as tumors or acromegaly; thyroid disorders; chorioepithelioma of the testis; hysterectomy; encephalitis; and ingestion of certain drugs, including oral contraceptives, phenothiazines, reserpine, and methyldopa (Barnes, 1966). Galactorrhea has been a presenting sign of cirrhosis of the liver (Chowdhury et al., 1997).

The occurrence of galactorrhea with amenorrhea or abnormal menses (see the Hippocratic aphorism at the beginning of this chapter) may lead to an early diagnosis of a prolactinoma. Development of galactorrhea in a woman taking oral contraceptives mandates a prolactin determination. Sometimes, women are started on oral contraceptives because of abnormal menses resulting from a prolactinoma; such women are likely to develop amenorrhea when the pill is stopped.

About 50% of patients with acromegaly have hyperprolactinemia; growth hormone itself is a potent lactogen (Melmed and Kleinberg, 2007).

Galactorrhea–amenorrhea syndrome has been described with multiple sclerosis (Tanaka et al., 1997) and after spinal cord surgery; in the latter case, it was attributed to activation of the afferent neuroendocrine pathway (Faubion and Nader, 1997).

Gynecomastia

"Gynecomastia" means "a woman's breasts," and it is therefore an abnormality only in men.

Prevalence

It has been said that breast tissue cannot be palpated in normal adult men. However, studies have shown that some palpable gynecomastia is quite common, being found in about 36% of normal young adult men (Nuttall, 1979). It occurs commonly at the time of puberty, and it may be more pronounced unilaterally. Between the ages of 14 and 14.5, 65% of healthy Boy Scouts had some gynecomastia (Nydick et al., 1961). In a study of 214 hospitalized adult men (Niewoehner and Nuttall, 1984), gynecomastia was found to be related to age, the prevalence being highest (72%) in men aged 50 to 69 years, and increasing with body mass index (weight divided by the square of the height). An autopsy study revealed gynecomastia in 40% of an unselected series of 447 men, although the breasts were grossly enlarged in only four of these (Williams, 1963).

From the above, we can see that how one searches determines what one finds. Because so many of the negative gynecomastia evaluations are performed on men whose breast tissue is grasped from the side (and may in fact be only fat and not glandular tissue), I have modified my approach as follows: I place my finger in the nipple and invert it. If my finger does not encounter a bud of glandular tissue (not fat), I do not describe the patient as having gynecomastia no matter what the external contour. While it is impossible to correlate this technique with any of the above methods (or them with each other), I have not gone on any wild-goose chases since adopting it, while still adhering to the rules listed below under "Significance." This author notes, however, that there is zero tolerance for missing breast cancer these days. A mammogram will definitively answer the question of whether there is a concern and a need for further investigation as with a needle biopsy.

Etiology

Gynecomastia is believed to result in some cases from a decrease in the ratio of testosterone to estrogen. Thus, gynecomastia is a common finding in male neonates owing to the effect of maternal estrogens. As adipose tissue increases, more androstenedione is converted to estrone, explaining the relationship of gynecomastia to body mass index.

Drugs associated with an increased prevalence of gynecomastia include beta-blockers, spironolactone, quinidine, nitrates, cimetidine, antacids, steroids, and heparin, but all of these except cimetidine were associated with an elevated body mass index (Niewoehner and Nuttall, 1984). Ketoconazole and alkylating agents are believed to cause gynecomastia by blocking testosterone synthesis. Other drugs that may cause gynecomastia include busulfan, ethionamide, isoniazid, methyldopa, tricyclic antidepressants, penicillamine, angiotensin-converting enzyme inhibitors, diazepam, marijuana, and heroin (Wilson, 1994). Newer drugs that cause gynecomastia include selective serotonin uptake inhibitors and proton pump inhibitors. Body-building steroids can cause gynecomastia; testosterone is metabolized to estrogen (A. Lanfranchi, *personal communication*, 2009).

In an autopsy series, gynecomastia was significantly associated with certain prostatic and testicular abnormalities (including untreated prostatic carcinoma), adrenocortical hyperplasia, thyroid changes, pancreatic islet and pancreatic duct hyperplasia, cirrhosis of the liver, and diabetes mellitus (Williams, 1963).

Significance

Because gynecomastia is such a common finding, the issue is not whether it is present but whether it requires a workup. Symptoms or signs that point to a need to investigate gynecomastia include pain, rapid breast enlargement, an eccentric or hard irregular breast mass, or a testicular mass (Niewoehner and Nuttall, 1984).

This author would recommend a mammogram for a lump felt by doctor or patient.

Appendix 15.1

Predictive Value of the Results of Screening Mammography

Given a sensitivity of 87%, a specificity of 93%, and a breast cancer prevalence of 0.8%, we prepare a 2 × 2 contingency table as follows:

In a population of 1,000 women, 8 will have breast cancer and 992 will not.

TP = 7	FP = 70
FN = 1	TN = 922

TP is true positive, FP is false positive, FN is false negative, and TN is true negative.

Thus, the predictive value of a positive test = [TP/(TP + FP)] = 0.09 or 9%, and the predictive value of a negative test = [TN/(FN + TN)] = 0.9989 or 99.89%.

Appendix 15.2

Results of Testing Nipple Discharge for Occult Blood

On the basis of the finding of a 100% sensitivity of the test for occult blood (16/16 in the study by Chaudary et al., 1982) and the 100% predictive value of a negative test (in the Atkins and Wolff study), patients with a negative test (and no lump) might be observed, although in one study, at least one patient developed Paget disease of the breast several years later (Chaudary et al., 1982), again illustrating the point that no test is perfect in medicine. The test is not highly specific [TN/(TN + FP) = 69/(69 + 199) = 0.26].

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CHAPTER

16

The Chest

The greatest and most dangerous disease, and the one that proved fatal to the greatest number, was the consumption.

—Hippocrates, *Of the Epidemics*

Points to Remember:

- Diagnosis of pulmonary function begins with observing the patient's posture, color, habitus, respiratory motions, and use of accessory muscles of respiration.
- In a patient with asymmetrical findings on examining the chest, first try to determine which side is abnormal.
- Changes in physical findings may precede visible changes on chest radiographs, both in the development and in the resolution of a disease. Some auscultatory findings may be more sensitive than radiography. Additionally, the physical examination can be repeated much more frequently than radiography.
- Solid substances transmit sound better than air-filled substances.
- The dimensions of breath sounds are timing, location, amplitude, pitch, tonality, and repeatability.
- Diagnoses that can be rapidly fatal if not treated promptly include airway obstruction, tension pneumothorax, and pulmonary embolism.
- Severe pulmonary embolism can present with minimal symptoms or signs; a high index of suspicion is imperative.

The physical principles underlying some of the material in this chapter are summarized in the introduction to the synthesis section and in the discussion of pitch.

Inspection

Posture and the Use of Accessory Muscles of Respiration

Certain observations, such as what position the patient assumes for the most comfortable breathing, are generally made while noting the patient's general appearance (see Chapter 5). The posture assumed by a patient with chronic obstructive lung disease to improve respiratory mechanics is shown in Fig. 7-1.

Look at the sternocleidomastoid and other accessory muscles (especially in a bed-bound patient who cannot brace himself by leaning forward). In general, their use appears to signify that the forced expiratory volume in 1 second (FEV_1) is decreased to 30% of the normal or less. In one study of asthmatic patients, sternocleidomastoid muscle retraction was the only sign that correlated with the pulmonary function results, appearing at a FEV_1 between 1.0 and 1.5 L (McFadden et al., 1973). With chronic compensatory use, the sternocleidomastoid muscles may develop noticeable hypertrophy (i.e., they will be thicker than the patient's own thumb).

Shape of the Thorax

Increased Anteroposterior Diameter

An apparent increase in the anteroposterior (AP) diameter is also referred to as a *barrel chest* or *pulmonary kyphosis*. It occurs in pulmonary emphysema (or in patients with "senile kyphosis"). Interrater reliability for this sign is about 70% (Fletcher, 1952).

Actually, the AP diameter is not increased. In a study of 25 patients with emphysema, 22 patients with other diseases, and 16 normal subjects (Kilburn and Asmundsson, 1969), two physicians agreed that the 25 emphysema patients had an increased AP diameter. However, measurement of the actual inspiratory and expiratory AP diameters by chest film and by direct measurement with calipers revealed no significant differences between the three groups. Because the emphysema patients weighed about 30 pounds less than normal subjects, the "increased" AP diameter may be an illusory, albeit constant, field/image effect due to a decreased abdominal AP diameter.

Increased AP diameter does occur in acromegaly, along with kyphosis, as shown in Fig. 16-1.

Deformities of the Thoracic Cage

Pectus Carinatum ("Pigeon Breast")

In pectus carinatum, the sternum protrudes from the narrowed thorax. Although it is thought of as a benign sign, in one study, 45% of the patients with pectus carinatum had associated abnormalities that could be seen on a chest roentgenogram (Pena et al., 1981).

The deformity may be isolated or familial or associated with anomalies of the diaphragm or with a specific disease such as acromegaly (Robicsek et al., 1979), childhood rickets, Noonan syndrome (Mendez and Opitz, 1985), or Marfan syndrome. It is also associated with scoliosis.

Pectus Excavatum

The vulgar term for pectus excavatum is "funnel chest." The inferior sternum and xiphoid are retracted toward the spine, producing either an oval pit near the infrasternal notch or a more extensive distortion. In one series, associated chest roentgenogram abnormalities were present in 72% of cases of pectus excavatum (Pena et al., 1981).

It has been associated with Noonan syndrome (see Fig. 11-1), Marfan syndrome, rickets, tracheomalacia (Lane et al., 1984), bronchomalacia (Godfrey, 1980), scoliosis, and congenital heart disease (Godfrey, 1980; Robinson, 1970), including prolapse of the mitral valve (see Chapter 17).

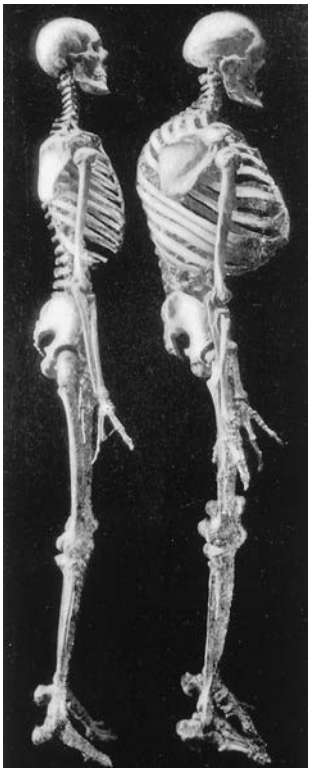

FIGURE 16-1 **A** (on left): Normal skeleton. **B** (on right): Skeleton of an acromegalic patient, "Osborne's case," at the Yale Medical School, showing kyphosis, an enormous AP diameter of the thorax, and great obliquity of the ribs. (From Osborne OT. Acromegaly. In: Buck AH ed. *A Reference Handbook of the Medical Sciences.* Vol. 1. New York: William Wood and Company; 1900:86–97, with permission.)

Kyphosis and Scoliosis

Abnormalities of the thoracic spine curvature are common. Kyphosis (forward curvature) and scoliosis (lateral curvature) by themselves rarely lead to respiratory or cardiovascular complications. However, kyphoscoliosis, if severe, is associated with pulmonary hypertension and cor pulmonale, symptoms and signs of which usually do not appear until the fourth or fifth decade (Fraser and Paré, 1970).

Obesity

The obesity alveolar hypoventilation syndrome (pickwickian syndrome) occurs in extremely obese persons (BMI > 35 kg/m^2). In one series, patients weighed 222 to 462 pounds (Baum, 1974). The syndrome occurs in 48% of hospitalized patients with a BMI > 50 kg/m^2 (Nowbar et al., 2004). Findings include daytime hypercapnia (PCO_2 > 45 mm Hg), cyanosis, periodic respiration, sleep-disordered breathing in the absence of significant lung or respiratory muscle disease, muscular twitching, an increased central venous pressure, hepatomegaly, and peripheral edema. Chest expansion is limited. The loss of as little as 25 pounds of weight may lead to marked improvement.

A "true Pickwickian" may have an abnormality in central ventilatory control, with an inherent blunted responsiveness to hypercapnia. However, in many cases, the syndrome coexists with obstructive sleep apnea, which was discussed in Chapter 13. The key question may be, "Does the fat boy snore?" The hypersomnolent messenger boy in *The Pickwick Papers* by Charles Dickens did snore: He "goes on errands fast asleep, and snores as he waits at table" (Millman, 1986).

Prompt diagnosis and treatment are important because untreated patients have a high mortality rate. Compared with eucapneic patients with sleep-disordered breathing and morbidly obese eucapneic patients, these patients have an increased risk of developing serious cardiovascular disease, including pulmonary hypertension and cor pulmonale (Nowbar et al., 2004).

Respiratory Motions

Signs of Small-Airway Disease

Dyspneic and tachypneic persons with small-airway disease breathe in a pattern that is observably different from that exhibited by other dyspneic and tachypneic persons.

To acquaint yourself with the normal pattern of tachypneic breathing, exercise to the point of breathlessness, and then observe yourself in the mirror with your chest nude. Notice that your entire chest is moving and that you are taking deep breaths.

Patients with small-airway disease, in contrast, tend to "breathe off the top." (The accessory muscles help them do this.) They take many small breaths from a position of relative inspiration but never seem to take very deep ones. If they do start to take deep breaths, they develop air trapping during expiration.

At end-expiration, the high transbronchial pressure can collapse the diseased terminal bronchioles, causing air trapping (and perhaps producing audible signs, see later in this chapter). These patients tend to exhale with pursed lips. In this way, they increase expiratory airway resistance and thus the pressure in the small collapsible airways, preventing collapse. Pursed lip breathing can lead to an increase in tidal volume, an increase in oxygen saturation, and a decrease in dyspnea. It reduces breathlessness by lengthening expiratory time and total time of the respiratory cycle (Bianchi et al., 2004). Because the airways are not at risk of collapse during inspiration, many patients who do purse their lips do it, quite unconsciously, only during expiration. This is a form of self-administered positive end-expiratory pressure (PEEP). Review Fig. 7-1 for the posture frequently assumed by patients with chronic obstructive lung disease.

Chest Expansion

Asymmetric Expansion: A Method

1. To compare the expansion of the two sides of the thorax in inspiration, stand behind the patient, whose head should be facing directly forward, and touch the *lateral* thorax with your hands. *Do not* place your hands posteriorly as instructed in most textbooks because if you do you will miss about half the cases of unilateral restrictions (and additionally will miss many patients with bilateral restriction).
2. Watch your hands as the patient inhales. Do not press or offer resistance to the thorax. Asymmetric chest expansion is a useful sign that may be more easily detected by palpation, as described below. Laënnec noted the importance of this "volume sign" as evidence of restriction, and he even had an illustration of it

(Plate VII, Laënnec, 1821). He used it to figure out which side had the "pleurisy."

Symmetric Expansion: A Method

Restricted symmetric expansion may be quantitated by measuring with a tape measure (preferably a spring-loaded one) placed at the nipple line the difference in the circumference of the chest between end-expiration and end-inspiration.

The normal value has been stated (without citing data) to be 5 cm (about 2 in.) in the absence of emphysema (regardless of chest size!) (Fries, 1985). An expansion of 1.5 in. or less is considered definitely impaired (Fletcher, 1952). However, using a less stringent standard of 2 in., one would probably detect all of the individuals with impaired expansion, at the cost of garnering a few false positives. Unfortunately, the error on repeated examination is usually at least 1 in. (Fletcher, 1952). So as a general rule, a single measurement of less than 1 in. is definitely abnormal and a measurement of more than 3 in. is normal.

Symmetrically impaired chest expansion (<2.5 cm or 1 in.) can be an early sign of ankylosing spondylitis, and it should be sought in young men presenting with low back pain (Fries, 1985).

Intercostal Spaces

Normally, the intercostal spaces bulge inward during inspiration and outward with expiration. This may be easily observed in a thin classmate.

An exaggeration of the inspiratory retraction occurs in patients with obstructive or restrictive lung disease because there is an imbalance between (a) the ability of the respiratory muscles to create a negative intrapleural pressure and (b) the impaired ability of the lungs to expand.

Focal exaggeration of inspiratory retraction indicates a regional imbalance in the two opposing forces discussed above. There might be a local obstruction with increased airway resistance, say in one of the bronchi. Or there might be a flail chest. In the latter, the affected ribs are separated from the rest of the chest, either by a fracture or by separation of the cartilages and thus, by their heightened inspiratory retraction, become a passive indicator of the underlying negative intrapleural pressure.

Focally exaggerated retraction of the cardiac interspaces, concordant with ventricular systole, is the Broadbent sign of constrictive pericarditis.

Unilateral or local loss of inspiratory retraction suggests an underlying consolidation, tension pneumothorax, or pleural effusion. In fact, even the small pleural effusion within the hydropneumothorax shown in Fig. 16-11 produced this sign.

Exaggerated expiratory bulging of the interspaces results from a mechanism similar to that of heightened inspiratory retraction. Diffuse expiratory bulging suggests that a positive intrapleural pressure is being effectively transmitted through the chest wall but that the lungs are not being emptied. This is a sign of increased expiratory airway resistance, either chronic (as in emphysema) or acute (as in asthma).

Focal expiratory bulging may be seen on the side of a tension pneumothorax or over the area of a flail chest. Constant focal bulging throughout all the phases of respiration can be caused by the accumulation of massive amounts of pleural fluid or very rarely by the underlying pulmonary consolidation.

Focal systolic bulging over the precordium is discussed in connection with the palpation of the point of maximum impulse (PMI) (Chapter 17). Focal systolic bulging anywhere else is a sign of an arterial aneurysm.

Respiratory Paradox

Normally, the abdominal wall moves passively outward during inspiration as the descending diaphragm squeezes the peritoneal contents down and out. Then, the abdominal wall retracts during expiration as the diaphragmatic piston returns to its resting position.

In weakness or paralysis of the diaphragm, most commonly owing to overwork in severe chronic obstructive lung disease, inspiration finds the helpless diaphragm being passively sucked upward as the intercostal muscles do the work of inspiration. Now the abdominal wall retracts during inspiration. This is called *respiratory paradox* (Macklem, 1982). The sophomore who observes this sign of diaphragmatic fatigue should immediately ask his resident to see the patient because the patient may be in need of mechanical ventilation.

False positives may be seen in vain persons wearing swimsuits who hope to be noticed. Such persons voluntarily contract the abdominal muscles during inspiration, as may be detected by palpation.

Respiratory Alternans

When the diaphragm is mildly impaired, it may work for a few inspirations and then fatigue for a few. When this happens, the abdominal wall may move out normally for a few inspirations and then paradoxically move inward for a few inspirations until the diaphragm is again rested. This sequence of events is called *respiratory alternans* (Macklem, 1982).

There are some marginal patients in whom respiratory paradox or alternans can be seen only in the perfectly erect position because when they lean forward (or rarely when they are supine) the increased intra-abdominal pressure can increase the dome of the flattened diaphragmatic leaves. This may improve efficiency to a degree that, in these marginal cases, allows the disappearance of the signs (Sharp, 1986).

Subcostal Angles and the Hoover Chest Sign

The subcostal angle is the angle between the xiphoid process and the right or left costal margin, as shown in Fig. 16-2.

A second, less strict definition states that the subcostal angle is the angle between the right and left costal margins viewed from the patient's feet. This more than doubles the size of the angle, allowing for easier appreciation of the changes. Also, the xiphoid process may be difficult to observe in obese patients. Finally, this second definition alleviates the problem of deciding which portion of the curved costal angle should be chosen for the chord or tangent that defines the angle; one simply takes any segment available and matches it to the facing side. However, several of the variations on the Hoover sign to be discussed below depend upon comparing the right and left subcostal angles, so this second definition will not be useful in that context.

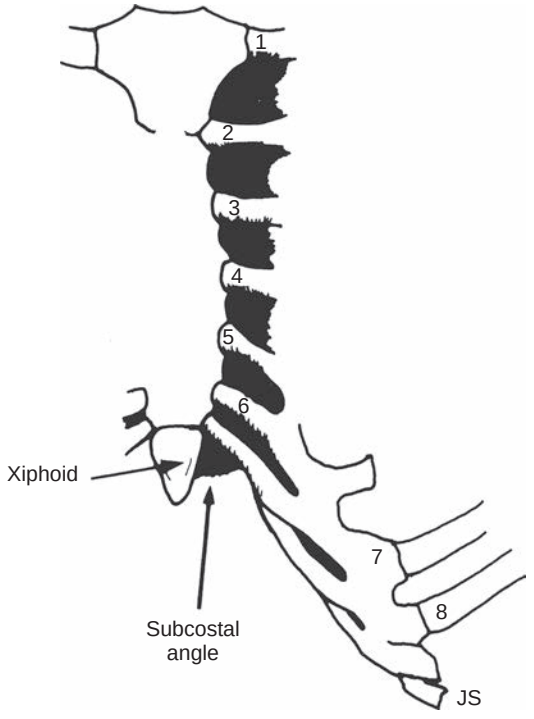

FIGURE 16-2 The subcostal angle.

A Method

1. With the patient supine, sit or stand at his side and lean over toward his midline.
2. Lightly rest your right hand on the patient's left hypochondrium, with your thumb on the medial costal margins and the remaining fingers superiorly toward the patient's head.
3. Lightly place your left hand on the patient's right costal margin, symmetric to your right hand.
4. Instruct the patient to take a deep breath. Normally, both hands will swing out symmetrically during inspiration and the thumbs will form a more obtuse angle, returning to a more acute angle with expiration. The hands are not to offer resistance but only to increase your appreciation of the change in angle. With practice, you can observe this sign without using your hands.

Interpretation

The subcostal angle during normal inspiration is determined by the balance between two forces: (a) the lateral pull on the costal margins because of the intercostals and (b) the contrary action of the diaphragm normally exerted only at end-expiration when the diaphragm is flat. If the diaphragm is sufficiently flattened in early inspiration, as in emphysema, its fibers pull horizontally (coronally) rather than vertically (like a longitudinal piston) and might overcome the action of the intercostals, causing the costal margin to move *medially* during inspiration and causing the angle to become more acute (the Hoover sign).

This sign has also been called the "Hoover groove" because one can sometimes see a groove as the flattened diaphragm pulls inward. In rachitic children, this becomes a constant groove called the "Harrison groove." The most common cause of the Hoover sign is severe obstructive lung disease. "... When pulmonary emphysema is responsible for severe air hunger and dyspnea, the entire phrenic leaf on both sides is sufficiently flattened so that both costal margins in their entire extent are drawn toward the median line during inspiration" (Hoover, 1920a).

Hoover sign provides valuable prognostic information in patients with airway obstruction. It occurs in up to 70% of patients with severe airway obstruction and is associated with increased BMI, severity of dyspnea, and frequency of exacerbations. It has a sensitivity of 58% and a specificity of 86% (Johnston et al., 2008).

Patients with pure, severe restrictive pulmonary disease (who do not have flattened diaphragms) *do not have* the Hoover sign. Although they may have very little thoracic expansion, their subcostal angles will move in the correct way, insofar as they move at all.

The Hoover sign, if the result of emphysema, may be lost in marginal cases if the patient leans forward (or sometimes if he simply is recumbent) because the increased abdominal pressure causes the diaphragmatic fibers to take a more convex orientation (Sharp, 1986).

Globular enlargement of the heart, as in dilated cardiomyopathy or rheumatic mitral valve disease with supervening right-sided heart failure, could also flatten the diaphragm sufficiently to cause the Hoover sign (Hoover, 1920b). Or paralysis of the intercostal muscles could cause the balance of forces to shift in favor of the diaphragm (Hoover, 1920a).

However, this sign seems to be more valuable in pulmonary diseases than in heart disease or neurologic disease because there are other ways (palpation and percussion) of estimating heart size and muscle strength but fewer bedside techniques to show what the diaphragm is doing.

Variations on the Hoover Sign

Hoover also described a number of variations on the Hoover sign, all based on the same principle (Hoover, 1920b).

Paralysis of the diaphragm, as in muscular dystrophy, or a rare case of poliomyelitis, will lead to an exaggeration of the normal symmetric outward movement of the costal margin. An asymmetric outward movement of the costal margins may be caused by several etiologies:

1. The side that moves more (*laterally*) may have had an increase in its hemidiaphragmatic curvature owing to something pushing up from below or from massive atelectasis of the lung pulling up from above. Hoover found the sign especially useful in cases of subphrenic abscess, in which the abscess pushed the hemidiaphragm up into a dome of greater curvature, thus allowing the intercostals on that side to win the tug-of-war. *Beware*: One case of a subphrenic abscess was reported in which the hemidiaphragm was scarred against the chest wall and the adhesions caused the diaphragm to exert a direct horizontal pull that moved the costal margin medially during inspiration. Another patient with a subphrenic abscess had an ipsilateral pyopneumothorax, which tended to push the hemidiaphragm down so that the two abnormalities canceled each other out, resulting in no observable abnormality of the costal margins during inspiration.
2. Unilateral *medial* movement will occur on the side that has a greatly depressed hemidiaphragm or paralysis of the intercostal

muscles. The former may occur with tension pneumothorax or pleural effusion.

3. Inspiratory narrowing of the costal angle with relatively normal movement of the more lateral costal margins may occur if the heart or pericardial sac is just enlarged enough to depress the subcardial portion of the diaphragm. Hoover believed that he could thus determine the cause of dyspnea in some patients with both emphysema and heart disease. If only the medial portion of the costal border moved medially (making the angle more acute) during inspiration but the lateral borders continued to move laterally, he attributed the dyspnea to the cardiac disease rather than the emphysema.
4. Asymmetry in the movement of the subcostal angle, when the lower and outer portions of the margins move laterally during inspiration, could result (left side moving less) from left ventricular enlargement in the absence of right ventricular enlargement (as in aortic insufficiency) or (right side moving less) right ventricular enlargement alone (as in pulmonary edema from phosgene poisoning, as Hoover learned about during World War I). This refinement may seem like gilding the lily to the modern reader, who must keep in mind that the cardiac lesions seen in the first quarter of the 20th century tended to be quite severe because they had to be diagnostically obvious, and there was no such thing as cardiac surgery.

Potential Usefulness of the Hoover Sign

Hoover's meticulous observations were confirmed by fluoroscopy. This later invention seemed to be more precise than inference from inspection; required less individual instruction, skill, and experience; and produced an external image judged to be more "objective" in the Cartesian sense. Thus, Hoover signs became a redundancy during the era when many physicians had fluoroscopy in their offices. With heightened concern about radiation doses and with changes in remuneration, fluoroscopy disappeared from offices, and it may be worthwhile to resurrect these inspiratory signs. They give dynamic information not available from any type of static single image.

The Litten Phenomenon and Sign

A Method

Have the (skinny) patient lie on his back on an examining table, with his head toward the window or some other light source so that the lateral chest walls are illuminated brightly but obliquely. As you observe the interspaces in the lower portion of the chest on one side, have the patient take a deep breath. A rippling shadow may be seen moving down the intercostal spaces with each deep inspiration. (Rarely, a reverse ripple can be seen with expiration.) This shadow may be produced by the diaphragm itself or by some diaphragmatic–pleural interaction.

The Litten phenomenon may also be seen with a single strong overhead light if the thin patient is seated with his arms back away from the lateral aspects of the thorax or with his arms positioned above his head as for the Pemberton maneuver (see Chapter 14).

This test is less useful nowadays because it works only for asthenic individuals with prominent rib interspaces. We should remember that in the 19th century the great physical diagnosticians of central Europe practiced on clinic patients, many of whom were extremely emaciated, whereas 21st-century patients in the US tend to be better fed.

Interpretation

The Litten sign is positive when the diaphragmatic movement is seen on one side but not on the other. It may result from any cause of unilateral phrenic nerve palsy, or it may indicate unilateral lower-lobe disease (or subdiaphragmatic disease) severe enough to interfere with diaphragmatic excursion. Because the latter causes are usually readily apparent from the remainder of the physical examination, an isolated positive Litten sign is usually equated with hemidiaphragmatic paralysis.

Trachea

The trachea will shift from the midline only in cases of severe pathology.

A Method

With the patient sitting erect, visualize a line running from the symphysis mentis to the midpoint of the sternal notch. Ordinarily, the trachea will be on this line or slightly to the (patient's) right of this line. Your findings can be verified by palpation (*vide infra*).

Note that tracheal deviations may be missed if they are sought with the patient lying in bed.

Significance

With lobar or segmental atelectasis of almost any etiology, the trachea is pulled *toward* the side of the atelectasis. On the other hand, it will be pulled to the side opposite that of a pneumothorax, especially during inspiration (Light, 1983). Tracheal deviation is commonly seen in upper-lobe collapse but rarely can be seen in collapse of the lingula or lower lobes (J. Arnett, *personal communication*, 1998).

Using the physical examination to determine the location of the trachea is one way of distinguishing between pleural effusion and consolidation with bronchial obstruction. In massive pleural effusion, the trachea is pushed away from the side that has the auscultatory findings; in massive consolidation with bronchial obstruction, the trachea may be pulled (by atelectasis) toward the side with the auscultatory findings. False negatives (which lack a tracheal shift) occur in uncomplicated pleural thickening, as well as in *minor* degrees of effusion, atelectasis, or consolidation without bronchial obstruction.

The trachea may be pushed away from a goiter. This can be a useful clue to the presence of a retrosternal goiter.

The trachea may be displaced anteriorly by an aberrant right subclavian artery.

A confusing picture may be found in situs inversus, in which the trachea may "normally" be slightly to the left.

Pleural thickening with parenchymal scarring may be distinguished from pleural effusion because in the former the trachea may be pulled *toward* the diseased side.

In some cases of severe unilateral pleural scarring or severe unilateral parenchymal fibrosis, the trachea appears to be midline but shifts toward the side of the lesion during a deep inspiration.

Tracheal deviation may also be seen with scoliosis.

Venous Signs of Intrathoracic Disease

Although visible venous collaterals (comparable to those seen with portal hypertension and inferior vena cava syndrome) may not always appear in superior vena cava syndrome (owing to the size of the thoracic wall and the frequently acute nature of the condition), it is still possible to make the diagnosis at the bedside by methods described in Chapter 19.

When pulmonary tumors obstruct venous segments, one can see large anastomotic veins, as well as distended smaller veins, unilaterally over the chest wall ipsilateral to the tumor. One such patient with unilateral venous distention over his chest "tumor" turned out to have a retrosternal goiter. Another patient had an unusual pattern of chest wall venous distention bilaterally at the second interspace when he was in the standing position. This led the physician to seek and find egophony (*vide infra*) over an oat cell carcinoma. The ability to see such veins is enhanced by the use of red goggles (see Chapter 19).

The signs of corona radiata and venous stars have already been discussed in Chapter 7.

Palpation

Palpation of the Chest Wall

A mass in the chest wall might be a tumor, although it is rare to find one that is not already known to the patient. A mass might also be an abscess from a pointing empyema, tuberculosis of a rib, actinomycosis, or nocardiosis.

When an empyema is suspected, one should palpate the temperature of the overlying skin. A warm spot is a sign of empyema. The ancients used this fact by applying a slurry of wet clay over the thorax: the heat from the empyema would visibly dry the clay first over the area of empyema.

When the history is suggestive (trauma or a severe cough), palpate the ribs for acute fracture. Fractures of the lower ribs, 2 through 12, may be associated with intra-abdominal injuries, especially if two or more fractures are present. Fractures of ribs 1 through 3 may be associated with mediastinal injury (including the aorta). Cough fracture is a common event though often missed because displacement is seldom a feature. Frequently bilateral, it usually involves the axillary segment of the sixth to ninth ribs (Felson, 1973). You might find an area of point tenderness. If you support the patient's back with one hand and press on the sternum with the other, pain can sometimes be elicited at the untouched fracture site.

Other causes of localized tenderness include Tietze syndrome, which is a self-limited, painful, nonsuppurative swelling of one or more costal cartilages, usually the second, and the adjacent bone. (The term *Tietze syndrome* is sometimes used interchangeably with costochondritis, though some restrict the former to instances in which there is actual swelling as well as pain.) The pain can be produced by pressing over the involved costal cartilages or sometimes only one of them. Local anesthesia relieves the pain (but is ineffective at points where pressure does not reproduce the pain). Similarly, once the trigger point is located, corticosteroid injections can be used as part of a therapeutic–diagnostic test (Ausubel et al., 1959). The differential diagnosis of Tietze syndrome, which is of unknown cause, includes neoplasms.

Septic arthritis can involve the costochondral junctions. Patients with a history of intravenous drug abuse or sternotomy are particularly susceptible (Zapatero et al., 1988).

The differential diagnosis of Tietze syndrome includes neoplasms; mechanical causes such as scoliosis; or systemic conditions such as ankylosing spondylitis, other seronegative arthritidites, gout, or rheumatoid arthritis (Aeschlimann and Kahn, 1990).

The pain of costochondritis is different from the chest wall pain produced by pressing the intercostal muscles or that discomfort produced in the fragile bones of the elderly by pressure directly on the sternum. The latter maneuver can also provoke pain in persons with leukemia and other bone marrow diseases. Tenderness at the junction of the manubrium and the body of the sternum or in the sternalis muscle overlying the sternum may be caused by the sternalis syndrome (Semble and Wise, 1988).

Pressure over the xiphoid reproduces the pain of xiphoidalgia, along with its radiation, which may include the shoulder, back, epigastrium, or deep in the chest.

Sharp pain associated with hypermobility of the anterior end of a costal cartilage, most often the tenth rib, has been called the *rib-tip* or *slipping-rib syndrome*. Pain and a snapping sensation may be elicited by the "hooking maneuver." Hook your curved fingers under the ribs at the costal margin and gently pull anteriorly (Semble and Wise, 1988).

Chest wall syndromes such as those described above were found (unassociated with coronary artery disease) in 13% of patients admitted to one medical department complaining of chest pain (Bechgaard, 1981).

Costochondritis (defined as tenderness on costochondral or chondrosternal joints) was found in 30% of 122 consecutive patients presenting with chest pain in one emergency department. In only 50% of these did the induced pain reproduce the original pain. The acute myocardial infarction rate was 6% in the costochondritis group versus 28% in patients without costochondritis; obviously, the presence of chest wall tenderness does not rule out coronary artery disease (Disla et al., 1994).

Tenderness in the chest wall along a dermatomal distribution may be referred from the cervical or thoracic spine; pain from this source is rarely felt anteriorly (Dorman and Ravin, 1991).

Crepitus (literally, "crackling") due to small bubbles of air moving through the tissues (subcutaneous emphysema) in response to pressure may result from trauma to the trachea or the chest wall. It usually is painless. Subcutaneous emphysema feels like plastic packing material that contains air cells. You can actually feel the air bubbles move under your fingers during palpation. (See the discussion on mediastinal crunch [Chapter 17], although it is possible to have one of these signs without the other, depending upon the distribution of the air.) Iatrogenic trauma (e.g., tracheostomy or chest tube placement) is a common cause of this finding, as is pulmonary barotrauma from mechanical ventilation. A fractured rib puncturing the pleura is an important consideration in a patient with a history of community-acquired trauma.

Palpation of the Trachea

The significance of tracheal deviation is explained above.

A Method

Put your second and third fingers in the suprasternal notch and slide each as far laterally as possible to the heads of the clavicles. Is the distance from the lateral tracheal wall to the clavicular head the same on both sides? If so, the trachea is midline.

The various tracheal tug signs were discussed in Chapter 14.

Palpation of Costal Expansion

After assessing the inspiratory expansion of the thorax by watching the motion of your hands (*vide infra*), pay attention to feeling the excursion.

Every experienced examiner must often have perceived how much more distinctly he could palpate than see a disparity in excursion in symmetrical chest regions. This disparity is not due to a more delicate perception of the hand of differences in time or distance of excursion but to the perception of the comparative force of excursion. If one directs his attention to the comparative force of excursion, evidence will be obtained for disturbances in pulmonary ventilation that quite escape inspection.... There may be considerable stenosis of the main bronchus to a lung that will yield no other physical sign than diminished force of costal excursion on the affected side (Hoover, 1926).

Hoover (1926) also states:

> Further observations on [the excursion of the costal borders] lead to the conviction that the comparative vigor of excursion... is a more delicate test than the comparative extent of excursion. The delicacy of this test is shown by the fact that in normal subjects the subcostal angle widens symmetrically with inspiration, but the left costal margin moves normally with less vigor than the right. The reason for this is the fact that the subcardial diaphragm to the left of the median line is slightly less convex than to the right. The difference in convexity under normal conditions is not sufficient to cause asymmetry in extent of excursion of the two inner halves of the costal margins, but the less vigorous excursion on the left is clearly perceived if the two borders are alternately restrained. It will be perceived that the left moves with less vigor under the restraining hand than the right....

Tactile Fremitus

The term *tactile fremitus* is a redundancy in the same sense as "palpable thrill," or my favorite, "physical disease."[1] Nevertheless, because some students and textbooks use "fremitus" to refer to, variously, bronchophony, egophony, whispered pectoriloquy, and spoken pectoriloquy, it is necessary to state that within this text "fremitus" means vibrations that are perceived in a tactile, nonacoustic manner.

A Method

1. Standing behind the patient, instruct him to say, "toy boat" each time you touch him. It has been pointed out (Dock, 1973) that the custom of having the patient say "99" during the palpation of the chest arose from a misunderstanding of our medical ancestors, who during a postgraduate year in Germany observed patients being told to say "99" in German (i.e., *neun und neunzig*, the "eu" diphthong being pronounced as in our words "boy" or "toy"). The direct translation into English eliminates the diphthong and changes the spectral characteristic of the sound so that less energy is expressed below 80 Hz. (If the German speakers had wanted our "nine" sound, they could have asked the patient to say "nein" [no].) To best approximate the German, we should use the words "toy" or "boy." Some prefer "blue moon" or "boogie-woogie," but these have not been studied.

   This error has been perpetuated in textbooks for generations. Yet, even a broken clock gives the correct time twice a day. In a comparative study of "toy boat" versus "99," there were a few cases in which the relatively weak vibratory signals from "99" were just perfect to distinguish a small lesion whose presence was masked by the strong signal of the diphthong. Yet, for screening a large area of a thick chest, the diphthong was usually superior to the rarely more sensitive "99"; the latter also gave some false positives (Sapira, unpublished observations).

   Perhaps one could have the best of both worlds by asking the patient to say "nine boys."
2. Pressing the palmar aspect of your hands and fingertips *firmly* against the patient's chest, note the intensity of the vibrations over the apices, in the interscapular area, down the paravertebral areas, across the supradiaphragmatic areas, laterally up to the axillary areas (having the patient raise his arms at this point), and then anterior to the areas of the right middle lobe and the lingula. The last are the only two places where the vibrations may normally be asymmetric. (Wiener and Nathanson would add the interscapular areas; see later in this chapter.)

Vibratory Threshold in the Hands

It is said that low-frequency vibrations, such as those produced during the testing of vocal fremitus or by the cardiac impulse, are equivalent to a 128-Hz tuning fork and that the latter can be better felt by the "palmar base of the fingers" (the volar distal metacarpal heads) than by the tips of the fingers (DeGowin, 1965). This author's observations, especially in men, do not confirm DeGowin statement. In the lone scientific study that compared the fingertips to the "palmar base" across a wide variety of frequencies in healthy young persons of both sexes, the fingertips were *more* sensitive (Lofvenberg and Johansson, 1984).

This is an important finding because the method offered above produces a wide spectrum of frequencies, and it is not clear which frequency is altered when tactile fremitus is "decreased." In fact, 128 Hz would not be the best frequency to test for optimal function because that has been reported variously as 150 to 200 Hz (Goff et al., 1965) or 200 to 300 Hz (Lofvenberg and Johansson, 1984). The variability may be the result of studying groups with differing age and sex compositions because older persons have poorer vibratory sensation than younger persons (Goff et al., 1965; Roland and Nielsen, 1980), but the frequencies at which the threshold increases with age differ between men and women (Goff et al., 1965). The latter may explain why some report better vibratory discrimination for women (Roland and Nielsen, 1980), while others report better results for men (Goff et al., 1965).

There are situations in which the palmar base, the fingertips, or even the hypothenar surface of the hands seem to work better, and these are usually replicable between observers for any given

[1] If a thrill is not palpable, how can it be perceived (Dock, 1973)? If a disease is not physical, how can it manifest itself (Graham, 1967)?

patient. The more important issue is to avoid missing a positive physical finding. I am unaware of anyone who has ever missed a lesion because of using the method given above.

Another Method

Wiener and Nathanson (1976–1977) have difficulty comparing tactile fremitus from hands applied simultaneously to both sides of the chest. If you share this difficulty, you can use one hand applied sequentially in the same manner as one uses a stethoscope.

Caveats

A common mistake is failure to attend to the pressure exerted by the hand when checking for tactile fremitus in fat people. If one does not compress the fat equally on both sides, one can get very peculiar results. This is most likely to happen when checking with only one hand at a time and alternating from side to side. Of course, this is not a problem with thin people, who were the major subjects of the great European physical diagnosticians of the late 19th and early 20th centuries, and that may explain why this caveat does not appear in the ancient tomes.

If you do not examine for tactile fremitus precisely in the manner described, you will probably do no better than the 25% agreement reported in a study of 24 British physicians (Spiteri et al., 1988).

Wiener and Nathanson (1976–1977) repeat the caveat of Norris and Landis (1938) that fremitus is normally increased in the right interscapular area; that is, it is comparatively decreased in the left interscapular area. The explanation is originally from the textbook of Norris and Landis (1,000 pages on the examination of the chest alone), which was cannibalized by Leopold (1952).

> Fremitus is normally more intense over the right upper lobe than over the left because the trachea lies in immediate contact with the apex of the right lung, whereas on the left side it is separated by a distance of 3 cm by the interposition of the aorta, internal carotid artery, esophagus, lymphatic, and areolar tissue. Fremitus is normally increased in intensity in the second right intercostal space because of the proximity of the bronchial bifurcation and posteriorly between the scapulae because of the proximity to large bronchi. I have not found the asymmetries noted in the previous paragraph, but I do not use "99." I do use both hands simultaneously, ignoring all but the obvious differences between the two sides.

A Beginner's Interpretation of Tactile Fremitus

A beginner is advised to rate his findings of lateral disparity as definite or possible and to initially not use any of the latter in composing the differential diagnosis. Depending upon the number of chest examinations performed, the prevalence of pathology, and the quality of supervision, most students will require months to years to achieve a useful (i.e., better than radiographic) expertise.

A few general rules apply:

1. First pick the abnormal side, if you can.
   a. Any side that shows generalized inspiratory restriction to inspection may be assumed to be the abnormal side.
   b. The abnormal side can also sometimes be determined by the sign of tracheal deviation. (Unfortunately, there is usually no shifting if there was no restriction on inspection.)
   c. If all else fails, the abnormal side is assumed to be the one that shows a posterior or lateral palpable *segmental* abnormality. (Anteriorly, the heart may confound the decision.)
2. a. An increase in tactile fremitus over the abnormal side means that there is a direct solid communication from the bronchus, through the lung, out to the chest wall.
   b. A decrease means that there is an obstruction in the bronchial system or that the lung is displaced away from the chest wall by air, fluid, or solid material (such as fibrous scar) in the pleural space.
3. Pleural effusion can cause findings that may confuse the unwary. Sometimes pleural effusion at the base of the lung will push the lung up and compress it in a firm atelectatic band. While tactile fremitus will be decreased (compared with the normal side) at the base by the pleural effusion, the compressed (and therefore consolidated) lung at the top of the effusion may actually cause tactile fremitus to be locally increased. This phenomenon of a thin band of signs of consolidation above an effusion is discussed later, in connection with tubular breathing and egophony.
4. If you are still having difficulty with your interpretation, do not worry. Just record your findings and proceed with the rest of the examination. A large number of nondiagnostic findings are more useful than a very small number of more highly diagnostic findings (Sapira, 1981). The interpretation of all the findings in context is discussed at the end of this chapter.

Percussion

> *It was Laënnec's habit, when examining a newly admitted patient, laboring under pectoral disorder, to percute him in every part of the chest, both in front and at the back, as well as on either side. After which he would apply the ear to any part which resounded badly or imperfectly* (Grandville, 1854).

Percussion was used by the Hippocratic school and reintroduced by Leopold Auenbrugger in 1761 (*vide infra*). Throughout its history, the technique has been controversial. The most important controversy, because it is relevant to understanding the different results reported by various students of the technique, concerns the physics of sound production. One school of thought (the topographic percussion theory) holds that the percussion blow causes vibrations in the underlying organs. Guarino viewed it as a low-technology type of sonar: "Sound waves are reflected and refracted by a medium of different density and physical character lying within an otherwise uniform material… The concept is well-known to geophysicists in the studies of the earth's layers" (Guarino, 1982). An opposing theory (the cage resonance theory) holds that only the physical properties of the body wall and immediately adjacent structures control the sound vibrations (McGee, 1995).

Although these days physicians often neglect percussion and rely wholly on auscultation (or radiography), percussion can provide a rapid indication of intrathoracic problems in a patient who cannot take deep breaths owing to pain, weakness, or altered mental status.

Learning How to Percuss

There are two basic types of percussion: (a) the more common indirect (mediate) method, in which the examiner strikes his finger, and (b) the direct (immediate) method, in which the examiner strikes the chest wall with the percussing finger(s).

The four-finger immediate method was first demonstrated to me by Dr John De Groote of Mississippi. While it is useful for covering large areas of the thorax quickly, I find myself reverting to the one-finger mediate method, with which I have more experience, for the apices, the interscapular areas, and diaphragmatic descent.

Hoover championed another technique of percussion of the direct type. Because this method was designed for percussing the heart border, it is discussed in Chapter 17.

A Method

Place the third finger (pleximeter) of your left hand firmly against the surface to be percussed and then rap a pair of drum strokes on its distal phalanx using the tip of your right third finger as a mallet (the plexor). The first beat of the pair is strong; the second softer. The excursion of the plexor is up to 4 in. for the first stroke and less than 2 in. for the second stroke, but this varies widely with the percussor and the tissue that is being percussed. (This is really not a rule but only a general description of what beginners should try.) Some percussors strike only once (see Chapter 17).

Obviously, medical students with long fingernails are advised to clip them close, especially on the plexor hand.

Developing Your Skill

Some people use the second finger and some the third finger as the pleximeter. Some strike over the fingertip and some over the distal interphalangeal joint. Some strike with their third finger, some with the second, and some with two or three fingers, and I have even seen descriptions of percussion by persons who use a tiny hammer as a plexor. This leads to the Student's Rule of Percussion: There is no one correct way to percuss. Do whatever works best for you. It may help to remember a recurrent adage in percussion, attributed to Adolf Weil, that it is much easier to distinguish "something from nothing" than "more from less"; thus, if one percusses so lightly over a dull area that no note is produced, the same force of percussion will cause an audible tone to spring to life when a resonant area is encountered (McGee, 1995).

To facilitate each student in developing the percussion note that is best for him, I suggest finding someone who already knows how to percuss and have him teach you (and your partner) in the following manner:

1. Have the more experienced person percuss some portion of your partner's body.
2. Then, with his pleximeter finger still in place, *you* produce the note—one-handedly—by striking the more experienced person's finger. You should attempt to produce the same note. Are you hitting the same spot? Just as hard?
3. Put your finger as the pleximeter on your partner's body and let the more experienced person percuss it. At this point, your partner may wish to comment on how firmly you are pressing in comparison to the proficient person.
4. Switch fingers back and forth several times until you feel ready to do the percussion yourself (two-handedly). You should continue to strive to produce the same note that you heard the more experienced person produce. However, do not be discouraged if you are unable to do this at the beginning of the first learning session. It takes some people hours or even weeks before they can reliably reproduce the percussion note on demand. But once you have it, you will never lose it.

Common Errors

Common errors include excessive use of force by the plexor finger, insufficient pressure on the pleximeter finger, delivering the blow through a motion at the elbow rather than the wrist, hitting the middle rather than the terminal phalanx of the pleximeter finger, and failure to move away promptly as does a piano hammer. One suggested method for overcoming these errors is to have students percuss directly on a tabletop and then indirectly through a foam sponge to simulate the skin and subcutaneous tissue. In this way, students rapidly learn the importance of correct technique, such as appropriate pressure by the pleximeter finger, in producing a clear sound (Benbassat and Meroz, 1988).

How Are Changes Perceived?

The question of whether the percussionist accomplishes his purpose by noting changes in sound or by feeling changes in vibratory quality was once debated enthusiastically. Probably both answers are correct at times. There are some situations in which one can continue to percuss accurately through the noise now so frequently encountered in teaching hospitals. But with other patients and other tissues, one is completely dependent upon the acoustic part of percussion and thus requires a silent room. Whatever the contribution of fingertip sonar to the percussionist's ability to delineate underlying structures, it should be preserved in full because each of us needs all the help he can get. Accordingly, students who play steel-stringed guitars or who for other reasons have fingertip calluses on their left hand are advised to percuss with their hands reversed. Thus, the noncalloused, sensitive right fingertip is the pleximeter struck by the left hand's plexor.

A Musical Interlude and Pedagogic Instruction

Dr Auenbrugger was the inventor of percussion. Supposedly, he got the idea by observing a wine merchant percussing out a half-full barrel. Later, he began to practice this technique on his patients. Although there are no photographic records, history tells us that he percussed immediately with one hand, using all four fingertips. The finger did not strike the chest directly but through a silk cloth or a piece of clothing stretched tightly against it. (It was a modest age.) Although we find that startling today, it was probably an easier task to percuss through clothing on a malnourished clinic patient than it is to percuss the nude body surface of a contemporary patient, which may contain several extra centimeters of adipose tissue.

Auenbrugger meticulously checked his percussion results at autopsy and finally published his work in Latin, the language of scholars, in 1761. The medical community reacted to his *novum inventum* with the same initial indifference that has greeted most of the other major advances in our profession. In fact, he was severely criticized and forced to resign his hospital appointment (Roberts, 1995).

Auenbrugger, a wise man, went into private practice and that afforded him the opportunity to indulge in the Viennese court life. The two great musicians of the court were Mozart and Salieri. Of the two, it was Salieri who was considered the greater musician by his contemporaries, Mozart dying a pauper. And it was with Salieri that Auenbrugger wrote the opera "The Chimney Sweep." Allusion to this opera has been used to strengthen the myth that percussion could have been invented only by a musician. Unfortunately for the myth, Auenbrugger wrote only the words.

The final musical aspect of percussion derives from the story about the young stranger in New York who approached an old man on the street asking, "How do you get to the Metropolitan Opera House?" "Practice," said the old man. "Practice."

One must actually practice percussion in one's spare moments so as to obtain that minimal number of mindless physical repetitions requisite to a graceful and facile production, on demand, of the percussion note one wishes. You should practice before and after meals, before and after lectures, and during transportation. You can practice on furniture or on your own body.

The best piece of furniture for a novice to practice upon is a tabletop with a free-hanging edge or a table with an armrest supported in only one position, like the one-armed chairs in lecture halls. Obviously, the free-hanging edge will give a more resonant percussion note than the surface right above a supporting piece of wood. When you have mastered the percussion of such surfaces, whose relatively dull portions can be visually inspected from below, you are ready to advance to percussing plasterboard walls, knowing that the vertical studs are usually placed 18 in. apart (see Chapter 17).

It is also useful to practice upon one's own body. Percussion over the shin produces a flat sound, percussion centered over the liver or the heart produces a dull sound (or flat; see Chapter 17), percussion over the lung produces a resonant sound, and percussion over a stomach recently distended with a carbonated beverage will produce a hyperresonant or tympanitic sound. Thatcher compared the resonant sound with the note produced by striking a loaf of bread covered by a crust (the air cells of the bread being analogous to alveoli). Geigel compared the tympanitic percussion note with that produced by percussing a glass cylinder filled with very frothy beer (McKusick et al., 1955). Another way to produce a hyperresonant sound is to percuss one's own distended cheeks. You can alter the musical tone of the percussion note by opening and closing the mouth. When you can play a musical scale by percussing on your cheek, you are ready for the chest.

A Note on Studies of Physical Examination Techniques

Throughout this and other chapters, you will see the results of numerous studies attempting to validate (or debunk) various techniques of the physical examination. Results from one study to another may vary wildly. This could be because of an unmeasured, even unacknowledged, variable: the skill of the examiners. Often the methods section will recount the number of years spent in a given specialty or the fact that the examiners received some instruction in performing the technique before the study commenced. But had they *practiced*? Had they trained their hands and their ears, and had they correlated what they heard with the results of autopsy, surgery, radiographs, ultrasound, or other technologic studies?

Skill in surgery does not result from reading books or watching demonstrations and neither does skill in physical examination. One study showed that proficiency in cardiac auscultation correlated with the ability to play a musical instrument but not with a self-declared love for music nor with the habit of simply listening to music (Mangione and Nieman, 1997). The difference is in active, meticulous *practice*.

Percussing the Chest

A first principle of chest percussion is that posteriorly, nature has graciously provided us with a normal control hemithorax contralateral to the hemithorax with the lesion. Of course, this is not true anteriorly with the right middle lobe, so one must specifically examine the anterior surface of the patient's chest on the right, as described below.

Positioning the Patient

Do not percuss the chest with the patient positioned as shown in Fig. 16-3. For that matter, you should likewise never inspect, palpate, or auscult a patient so positioned, although the left lateral decubitus position is appropriate in situations described below.

This precept is based upon the fact that the dependent side may have false-positive signs produced by the acoustical damping and restricting properties of the bed or examining table that is touching the hemithorax. In difficult circumstances, one could conceivably examine the chest by rolling the patient from side to side, examining each hemithorax when it is superior. This would require a great deal of prior experience on the examiner's part because he would have to "remember" what the other side sounded like if he were to use the information provided by nature's control (the contralateral thorax). Moreover, Mazoon, who demonstrated the importance of cage resonance to the percussion note in autopsy studies, observed that any external pressure on the chest—from a pillow, a stretcher,

Figure 16-3 Improper positioning of the patient. (Do not attempt to percuss the thorax with the patient lying on her side like this. However, it may at times be helpful to percuss and auscultate the dependent lung of a patient in the left lateral decubitus position—see text.) ("Dawn" on Lorenzo de Medici's tomb, by Michelangelo.)

or an extra hand placed near the point of percussion—impeded chest wall motion and dampened the percussion note (McGee, 1995).

If the patient is unable to sit up because of stupor, muscular weakness, or some other inability to comply with the request, get someone else to hold him in a sitting position. Two persons standing by the sides of the bed, supporting the patient at the axillae, or sometimes only one person standing at the head of the bed holding the patient's extended arms can accomplish this. The latter is especially useful in otherwise cooperative patients who are simply weak. Please note that this is also exactly what we should do when we need to have a portable chest film taken (*vide infra*). We should not accept the patient's inability to sit or stand alone as an excuse for a poor chest film, nor should we accept it as an excuse for a poor physical examination.

A Note for the Senior Medical Student. When looking for internships, make rounds and observe the faculty at prospective hospitals. Do they examine only the anterior chest of a bed-bound patient, or do they examine the patient properly, with the house staff holding the patient up? This tells you what kind of data acquisition techniques you would learn in their programs.

A Method

1. With the patient sitting, begin by comparing the right and left sides posteriorly, working your way down the interscapular paraspinal areas. Do not percuss over the vertebral column (see Chapter 25 for direct percussion of the vertebrae).

   When you get inferior to the scapulae, percuss the bases very carefully alternating right and left, equidistant from the midline.
2. Next, instruct the patient to raise his arms above his head and percuss in the midaxillary line from the diaphragm up toward the axilla on one side, not switching sides until the percussion note changes. That is, do not switch from the right to the left lateral thorax with each pair of percussion notes but mentally "collect" all the percussion notes of similar tone on the one side before going up the midaxillary line of the other side.
3. Finally, percuss the axillae on both sides. These are the second most commonly missed portions of the lungs.
4. Next, move anteriorly and percuss over the right middle lobe, the area in which findings are most commonly missed because of failure to examine it. Because the percussion note over its contralateral control is altered by the heart, you may use the anterior segments of the right upper lobe for comparison.
5. Kronig isthmi are two hyperresonant bands passing over the shoulders like tank-top straps between the areas of dullness on the lateral neck and over the shoulder. They are easily percussed when one knows where they are. They may be examined either at the beginning of the chest percussion or at the end when one has again moved behind the patient in order to examine the diaphragms. The absence of the Kronig isthmus on one side is a strong evidence of consolidation or pleural disease in the apical segment of that lung. There are times when it is possible to detect slight differences between the percussion notes over the two apices. Invariably, the apex on the side with the duller note (not flat, just duller than the other side) has shown old pleural capping from prior tuberculosis on the roentgenogram. Acoustically, this makes no sense and is one reason to believe that there may be a tactile sensation that contributes to the perceived percussion note although one seems to be "hearing" a difference.

Although the above method moves from above to below posteriorly, you might be just as well advised to learn to percuss from below to above—if you have not already developed a method—for reasons given below. However, whichever starting point you use, the important issue is to compare one side with the other. Note that in healthy, nonobese individuals, the percussion note may vary somewhat depending on the zone. In general, the posterior zones are generally less sonorous than the anterior ones because of the effects of muscle layer, scapulae, and lesser elasticity of the ribs. The axillary zone generally yields a more resonant sound, sometimes frankly tympanitic (Yernault and Bohadana, 1995).

A Cautionary Note (*Mea Culpa*)

The great physical diagnosticians of yesteryear would be dismayed by the instruction to begin percussion at the top and work your way down. They taught, even in the US, that one should begin inferiorly and proceed superiorly (Byfield, 1921; Strouse, 1919). Their reasoning was as follows: First, it was felt to be easier to detect a border between dullness and resonance if one started from the area of dullness. (This principle was even extended to the percussion of the heart borders by some examiners.) Second, and more relevant to the present situation, one might miss a resonant zone caudad to the dullness (Fig. 16-4) if one stopped as soon as the dullness was

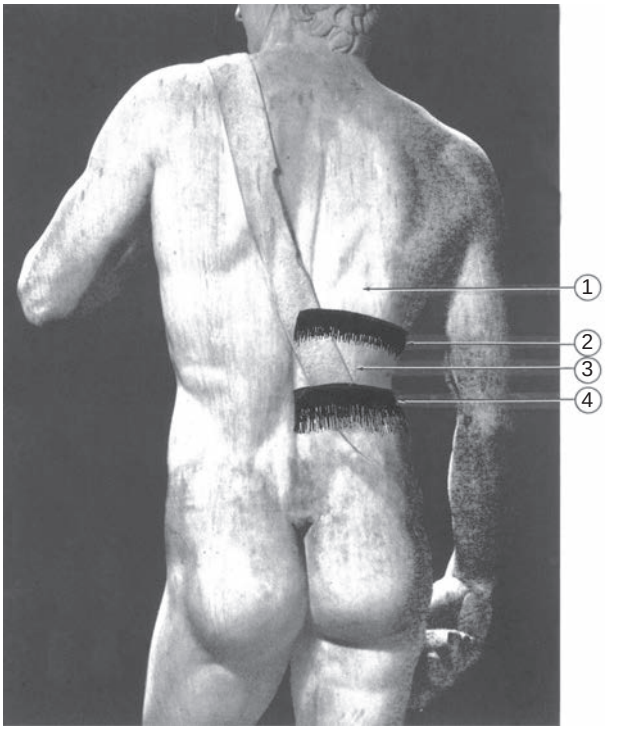

FIGURE 16-4 The odd-numbered light zones are resonant; the even-numbered dark zones are dull. These findings may occur in subphrenic abscess or in intrapulmonary consolidation. (*For the Advanced Student:* How would you make the distinction? Write your answer down before referring to the explanation in the text p. 289.) (David, by Michelangelo.)

reached. If you are not sufficiently thorough to be sure that you will not make this last mistake, percuss from below to above.

Significance of Dullness to Percussion

Dullness to percussion may signify consolidation of the underlying lung parenchyma, on occasion antedating radiographic abnormalities by hours or days (Yernault and Bohadana, 1995). Perhaps it may result from pleural disease: either fluid in the pleural space or, less commonly, fibrous scarring and thickening of the pleura. To distinguish parenchymal from pleural disease requires integration with other findings on the examination, as was discussed for tracheal position. (See the synthesis section below and Table 16.5.)

For the Advanced Student. Having found dullness over an area of the chest, you should immediately begin to think physiologically. The most likely cause of dullness is consolidation of the lung parenchyma, most frequently by pneumonia and/or neoplasia. In either case, the dullness will be ipsilateral to the side on which you have already found restriction on inspiration (by palpation). As a rule, you will already have noticed that the trachea is deviated toward the side of dullness *if* the bronchus leading to the consolidated area is *closed*. However, if the bronchus is *open* or if the involved area is small, the trachea may be in the midline. You may already have noticed changes in tactile fremitus over the area of dullness. If the bronchus serving the area of consolidation is open, tactile fremitus may be increased. But if the bronchus is obstructed by a tumor or by a glob of mucus, tactile fremitus could be decreased.

On the other hand, if dullness is not the consequence of parenchymal disease but rather of pleural fluid, you may obtain a constellation of physical findings exactly imitating those given above for consolidation with a closed bronchus except that the trachea will be pushed away from the afflicted side. (Sometimes the distinction between consolidation with a closed bronchus and pleural effusion can also be made by noting the location of the auscultatory finding of egophony—*vide infra*).

Finally, dullness may exist over any area of pleural thickening. This would be ipsilateral to any volume sign found on inspection or palpation. The trachea might be pulled to the afflicted side, and tactile fremitus might be decreased on the afflicted side, depending on the specific disease that caused the pleural thickening and its extent.

When a patient is suspected of having a pleural effusion, an old trick is to reexamine him in a lateral decubitus position. You may wish to mark out the line of dullness with washable ink before the second examination.

Have the patient put his "bad side" up for two reasons: (a) One never examines the inferior side if one examines a patient in the lateral decubitus position, and (b) the point of the test is that the pleural fluid, under the influence of gravity, will fall toward the mediastinum (Fig. 16-5). Then, areas that were previously dull to percussion may, after up to 30 minutes of the decubitus position, become resonant. On the other hand, dullness caused by consolidation with bronchial obstruction will not shift in this way.

In modern times, this distinction is more precisely made by the lateral decubitus chest film but at greater cost to the patient.

For the Very Advanced Student. Thompson is able to distinguish three levels of dullness to percussion, which he utilizes in combination with auscultatory findings to make rather specific diagnoses (Thompson, 1979).

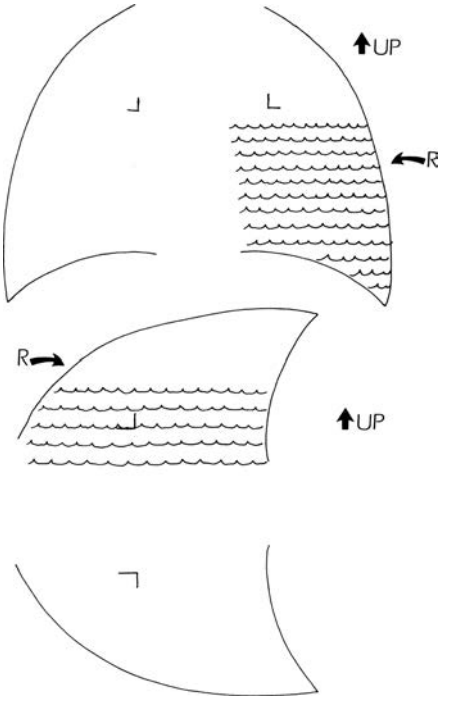

Figure 16-5 Diagram of nonloculated pleural fluid shifting from the right lower axillary line under the influence of gravity. Posterior view.

Red Herrings in the Percussion of the Chest

There are four situations in which percussion might lead you to diagnose a lung disease where there is actually none.

Pneumothorax

In a pneumothorax, the alveolar tissue beneath the percussed finger is replaced by air that has leaked into the pleural space. Because there are no alveoli to act as tiny sound baffles, the percussion note over the pneumothorax is even more resonant than usual. It sounds more like the percussion note over the gastric air bubble than like that over a normal lung. However, because we are comparing right to left as we percuss the lung fields, the neophyte might assume the duller side to be the abnormal one. In the absence of changes to inspection or knowledge of the coin test, below, this assumption would lead one exactly in the wrong direction. The error should be immediately recognized when the breath sounds are found to be absent or decreased on the hyperresonant side. If large, a pneumothorax may result in a decreased chest excursion, and subcutaneous emphysema may be present.

Recently, it has been suggested that the best place to check for the hyperresonance of pneumothorax is over the midclavicle, with the patient sitting or standing erect (Orriols, 1987).

Grocco Triangle

The Grocco triangle (Leopold, 1952) is a paravertebral triangle of dullness (relative, not absolute) whose right angle is formed by the spine and the normal diaphragm (Fig. 16-6). It is found contralateral to a pleural effusion but not to pleural thickening, and so may be used, if present, for the differentiation of the two processes. Note that it is a sign of relative dullness affecting the *normal* side.

The occurrence of the Grocco triangle is considered evidence to support the cage resonance theory. In a person without pleural

Figure 16-6 A Grocco triangle. (Guilliano de Medici, by Michelangelo.) (Shaft with *circle*, abnormal side; shaft with *arrowhead*, "normal" side.)

effusion, a Grocco triangle can be produced by external pressure over the opposite side of the chest, as from a hand or a bottle filled with water (McGee, 1995).

Other conditions that can produce a Grocco triangle (false positives) result from conditions that produce upward pressure upon the ipsilateral hemidiaphragm (ascites, gaseous distention, tumor, pregnancy, etc.), very large ipsilateral pericardial effusions, and massive contralateral pneumonia. If the patient has had a right pneumonectomy with an elevated right diaphragm (and liver), there may be a false positive on the left. This suggests that the mechanism has nothing to do with the "truly" normal lung but rather is an effect of acoustic muffling produced by the diseased side upon the "normal" side of the Grocco triangle.

Any bilateral basal pulmonary process may confound the Grocco triangle, thus giving a false negative (Byfield, 1921).

For the Very Advanced Student. One can sometimes find a spot of egophony within Grocco triangle. Again, this happens in pleural effusion but not in pleural thickening.

Skodaic Resonance

In 1839, Skoda, the Czech physician (Sakula, 1981), described an area of hyperresonance above a pleural effusion (Fig. 16-7):

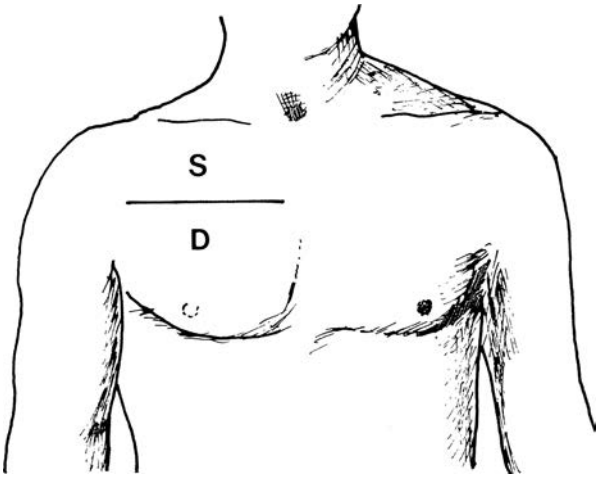

Figure 16-7 The area of skodaic resonance (actually hyperresonance) is above the area of dullness due to pleural effusion. This is customarily and more easily determined posteriorly. S, skodaic resonance; D, dullness.

> That the lungs, partly deprived of air, should yield a tympanic sound—and a nontympanic sound when the quantity of air in them is increased—seems contrary to the laws of physics. The fact is certain, however, and is supported both by experiments on the cadaver.... and also by this constant phenomenon, viz: when the lower portion of the lung is entirely compressed by any pleuritic effusion, and its upper portion reduced in volume, the percussion sound at the upper part of the thorax is distinctly tympanitic (Skoda, 1839).

The mechanism for skodaic resonance is unknown.

Now, if the dullness over an area of pleural effusion were incorrectly attributed to the diaphragm, then the skodaic hyperresonance above it might be misinterpreted as normal and the resonant, but duller, contralateral side might incorrectly be thought to be the site of pathology.

The Ewart Sign

The Ewart sign is dullness to percussion in the posterior lower left hemithorax, usually just under the tip of the scapula (Fig. 16-8). Because it results from a massive pericardial effusion distending the pericardial sac backwards and compressing the lung (the fluid-filled mass will not by itself produce the findings), it is obvious that all the physical signs of consolidation may he present.

The requirements for the Ewart sign include (a) a distensible pericardial sac that has not been previously scarred and (b) a massive chronic pericardial effusion that slowly stretches and distends it. Because patients now seldom go without medical intervention for sufficient time, the sign is found less frequently than in former years. Other percussive signs for pericardial effusion are discussed in Chapter 17.

It is not widely appreciated that massive pericardial effusion can also produce a right-sided Ewart sign, which should be called the *Conner sign* (Conner, 1926) (Chapter 17).

The Traube Space

The space described by Ludwig Traube (also noted for his sounds, which are discussed in Chapter 17) is a semilunar space over the stomach air bubble. Internally, it is bounded medially by

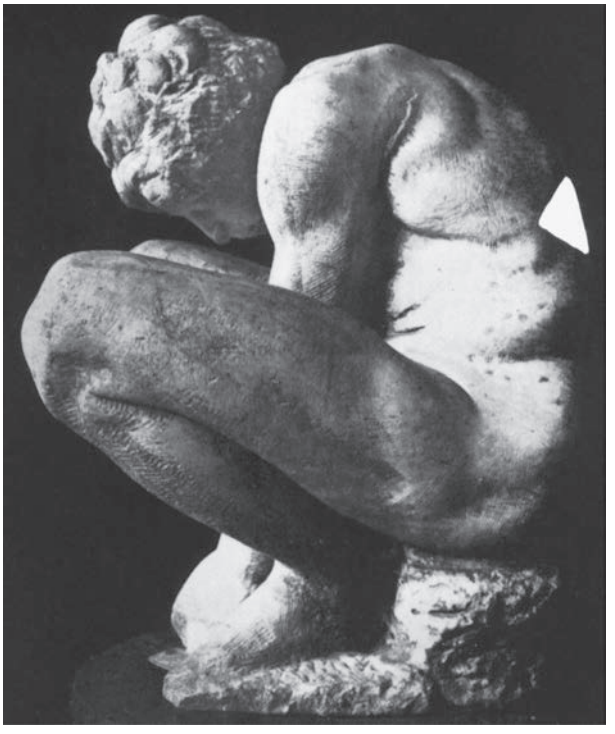

Figure 16-8 The *white triangle* indicates the area in which an Ewart sign would be found. While shown in its classic (left infrascapular) location, it should be noted that the Ewart sign is of variable size although it is always left and posterior (see text). (Squatting boy, by Michelangelo.)

the left lobe of the liver, laterally by the spleen, and superiorly by the lower border of the heart. On the surface, as shown in Fig. 16-9, it can be mapped by dropping perpendicular lines from the sixth rib at the costochondral junction and the ninth rib at the anterior axillary line to the costal margin. Over this space there should normally be, as described by Professor S. Jacoud in 1885, a "sharp tympanism with percussion, the absence of vocal vibrations by palpation and the absence of respiratory noise with auscultation" (Verghese et al., 1992). Findings described by Traube's student Fraentzel include the following:

> When the lung expands during inspiration, the half-moon space becomes smaller and thus shows that the lung is capable of expanding.
>
> A considerable increase in the semilunar space is usually a sign of immobility of the lower edge of the lung and thus serves as an indicator of scarring.
>
> In the presence of pleural effusion, the half-moon space may disappear and its reappearance heralds the beginning of reabsorption....
>
> During pneumonic infiltration of the entire lung, the half-moon space either remains intact or is only slightly narrowed (Verghese et al., 1992).

Jacoud added the caveats that reduction in the space may be the only sign of a subpulmonic effusion and that a reduction in the tympanism over the space could arise with pleural adhesions and not solely from pleural effusion. In the latter case, one should see retraction of the lower intercostal spaces with inspiration. It is said

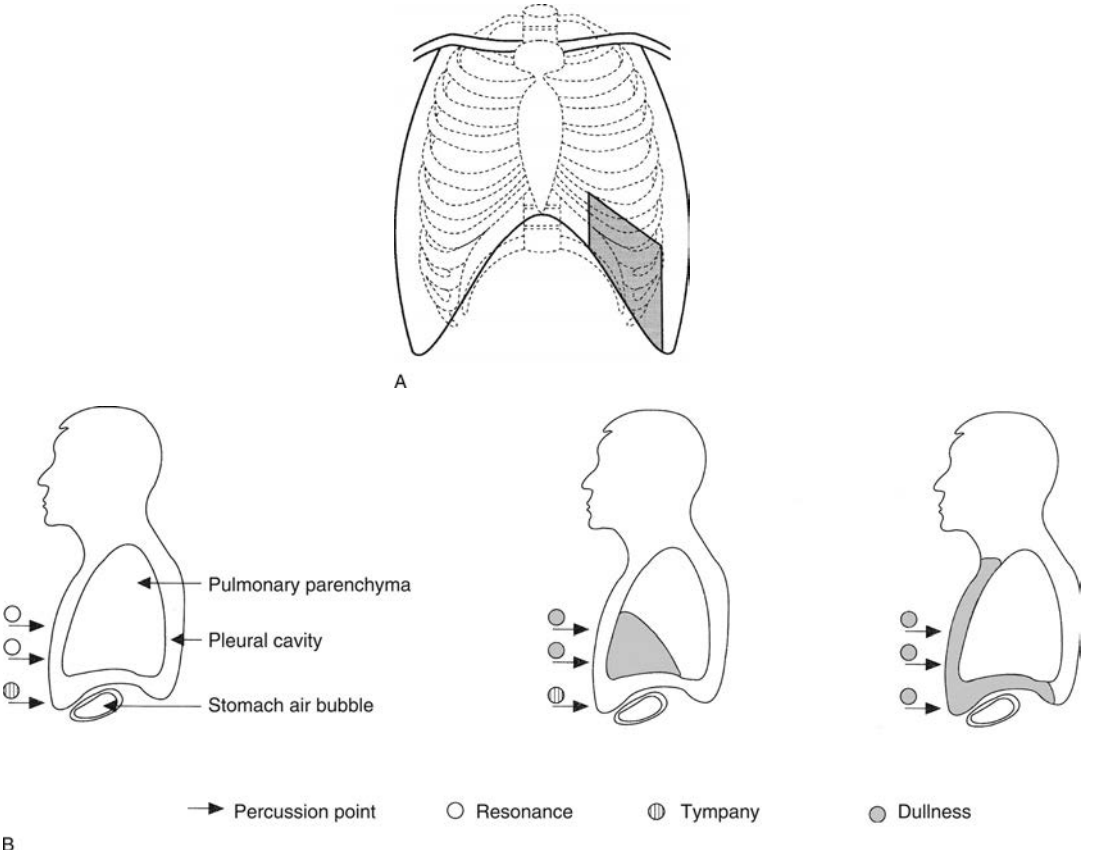

Figure 16-9 **A:** Surface anatomy of the Traube space. **B:** Schematic drawing of percussion findings in the left hemithorax in a normal lung **(left),** consolidation **(center)**, and pleural effusion **(right).** (From Verghese A, Krish G, Karnad A. Ludwig Traube: The man and his space. *Arch Intern Med.* 1992;152:701–703, with permission.)

that dullness over the Traube space is highly sensitive for effusions in an area where they can sometimes be missed by expert radiologists and that this has been confirmed on multiple occasions by thoracentesis.

The Traube space may be percussed with the patient either supine or sitting. For a patient with dullness in the left hemithorax, preservation of the Traube space suggests consolidation or atelectasis, while its obliteration suggests pleural effusion, except possibly in a patient with consolidation of the left anterior basal segment and the contiguous lingula.

Dullness in the Traube space could also be a sign of splenic enlargement (see Chapter 20), though this application was never described by Traube.

For the Attending. Findings such as this can cause "slack-jawed expressions of wonder on the faces of students and house staff when bedside diagnosis correlates with roentgenologic diagnosis—as if an insidious and deeply rooted distrust of the hands-on examination is being shaken. It is ironic that the ready availability of diagnostic technology has not, it seems, enhanced bedside skills but instead has encouraged their atrophy" (Verghese et al., 1992).

Percussing the Hemidiaphragms

Although percussing the hemidiaphragm is discussed separately for pedagogic reasons, it can be performed at the same time as percussion of the chest fields.

A Beginner's Method

1. Preferably with the patient standing, percuss the posterior inferior right lung field at least a hand's width from the midline, beginning over the resonant lung and moving inferiorly to the area of dullness, remembering the sounds.
2. Percuss on the left side for comparison, looking for the same resonant tone over the lung and the same dullness beneath the diaphragm.
3. Go back to the right, with the patient breathing very quietly or, preferably, holding his breath in expiration. Mark the point at which resonance changes to dullness.
4. Have the patient hold the deepest possible inspiration, and again moving in the same line from superior to inferior, find and mark the point at which the resonance changes to dullness. (Do not forget to tell the patient to exhale as soon as you are finished.)
5. Repeat for the left side. (You may have to switch back to the right to be sure you have remembered the tones correctly.)
6. Compare the diaphragmatic descent on the two sides.

Note that this is not an exact technique. One is more concerned with the relative positions of the right and left hemidiaphragms in expiration and deep inspiration.

When you become proficient, you will shorten this technique to just one pass on each side.

Actually, the hemidiaphragms cannot be percussed in their three-dimensional surface, nor do the body-wall insertions of the hemidiaphragms change during percussion. Rather, we determine the amounts of aerated lung near the body surface allowed by the changing shape of the hemidiaphragms and call these the "movement" of the "diaphragm" or of the "hemidiaphragms."

Interpretation

Normally, the percussed resting positions of the two hemidiaphragms are equally high, or the right hemidiaphragm is a little higher than the left. Usually, both of them appear to move the same distance. Evidence for bilateral movement may be lost in extremely fat persons, persons who normally breathe from a position of relative inspiration (the emphysematous), or individuals with severe restrictive disease who are unable to take a deep breath. It is possible in normals for the left hemidiaphragm to move a bit more than the right, but it is still an indication to search for disease on the right.

If the resting position of the left hemidiaphragm is higher, this is definitely abnormal. There are several possible explanations: (a) The left hemidiaphragm may be paralyzed. In this case, the right hemidiaphragm will move down with inspiration, but the left will move paradoxically: up with inspiration, down with expiration. (b) There may be a left lower-lobe lesion, causing an area of dullness that is indistinguishable from the left hemidiaphragm. (c) Rarely, a giant pericardial effusion will give a false-positive sign for an elevated left hemidiaphragm (the Ewart sign, discussed earlier in this chapter). (d) There may be a left upper quadrant abdominal mass, such as an enlarged kidney or spleen. In the last three conditions (b to d), the left hemidiaphragm, besides being higher, may seem to move only slightly, if at all, with respiration. (e) Very rarely, the patient may have situs inversus abdominalis.

If the right diaphragm is higher than the left, one might dismiss it as a normal variant. But all of the phenomena that can cause the left hemidiaphragm to be higher than the right and that can impede the respiratory excursions can also afflict the right side, *mutatis mutandis*. Because the right hemidiaphragm in normal persons is sometimes perceived to move less than the left, one cannot be dogmatic about the presence of pathology on the right side unless there is clear evidence of paralysis or of paradoxical motion. *Diminished diaphragmatic excursion* correlated with chronic obstructive pulmonary disease (COPD) in one study but not in another. In the positive study, a percussed excursion of less than 2 cm detected COPD with a specificity of 0.98 but with a sensitivity of only 0.12 (Badgett et al., 1993).

Other Opinions on Diaphragmatic Percussion

Wiener and Nathanson (1976–1977) state that the hemidiaphragms normally move 5 to 7 cm by percussion and that the right hemidiaphragm is normally percussed 1 or 2 cm above the left. Most will usually agree with these figures, but percussion yields sufficient interobserver variability, especially among young examiners, that one should not diagnose an abnormality based solely upon the violation of either of these putative ranges of normality.

Macklem has pointed out that a better way to detect failure of descent of the hemidiaphragm on one side may be by palpation of the abdomen. The side that fails to descend will generate noticeably less abdominal pressure on that side (Macklem, 1986).

The mediastinum will also shift away from the side of poor diaphragmatic descent, but most do not percuss the mediastinum in both full inspiration and expiration.

Reliability of Diaphragmatic Percussion

Two observers, one of whom was clearly the clinical superior of the other, determined diaphragmatic excursion by percussion in

29 patients (Williams et al., 1981). The authors were disappointed that they only agreed with each other (within 2 cm) about 60% of the time.

There are, of course, times when percussion of the diaphragm is, for one reason or another, as indeterminate as percussion of the heart size and contour may be. But there are other times when a disparity between the two sides is clearly detectable.

I agree that some persons are unable to percuss out diaphragmatic descent—my Aunt Minnie, for example.

Subphrenic Abscess

Before reading on, answer the study question in the legend to Fig. 16-4.

Bailey (Clain, 1973) could find four zones of percussion in a patient with a subphrenic abscess. The diaphragm lies between zones 1 and 3. Zone 1 is normal lung, zone 2 is compression atelectasis, zone 3 is gas in the abscess, and zone 4 is the normal dullness of the liver.

An internist would find this pattern of percussion more commonly in a right lower-lobe pulmonary consolidation that afflicts a superior posterior portion of the right lower lobe (viz., zone 1 is again the normal lung, zone 2 is atelectatic or consolidated lung, zone 3 is the most inferior portion of the right lower lobe, and zone 4 is again liver dullness). Here, the diaphragm is located between zones 3 and 4. To distinguish the two situations, simply listen over zone 3. If you hear breath sounds, you know that you are listening to the lung, that the diaphragm is between zones 3 and 4, and that the dullness to percussion in zone 2 must represent intrapulmonary consolidation not afflicting the most basal segments of the right lower lobe. If, on the other hand, there are no breath sounds in the resonant zone 3, you could assume that you are listening over the gas in a very large subphrenic abscess. (If the gas were in a pulmonary abscess, you might hear amphoric breathing, discussed later in this chapter).

Note that Bailey could never have made this distinction because the apparatus used for diagnostic purposes in his book (his Fig. 1) does not include a stethoscope, nor is the word "stethoscope" to be found in the index. (Conversely, the methods outlined in the present text would be all but useless for attempting to diagnose pericardial calcification. This teaches us that our diagnostic experience is totally dependent upon the tools we use to search for disease.)

Auscultation

Use of the Stethoscope

It is assumed that you have purchased a stethoscope (see Chapter 1) and have familiarized yourself with it for the purpose of taking blood pressures (Chapter 6).

A Method

1. Make sure that the room is quiet. There is no substitute for this step.
2. Be sure that the patient is properly positioned.
3. Always show the patient the courtesy of warming up a cold stethoscope chest piece before placing it on his naked body. (Obviously, you would not try to listen through clothing.) A simple way to accomplish this is by rubbing the chest piece in your hands. (Carrying the stethoscope in your pocket until you are ready to use it works even better.)
4. Ask the patient to take deep breaths with his mouth open. You may need to allow him to rest during the examination to avoid hyperventilation.
5. Most of the examination of the chest is for relatively high-pitched sounds and is performed with the firmly applied diaphragm. Make certain that you are not hearing artifactual sounds due to such things as hair rubbing against the diaphragm or air rushing through an incomplete seal formed by the bell.

   Sometimes, in thin patients with especially bony chests, a rubber-rimmed bell may work better. Apply the bell tightly, making a complete seal and also stretching the skin so as to form a diaphragm. If the stethoscope still does not fit perfectly, the edges may be sealed with damp cotton (Laënnec, 1821).
6. Listen systematically to all parts of the lung fields, beginning at the apices, comparing the sound on one side with "nature's control," the corresponding spot on the other side of the chest. Proceed posteriorly down through the interscapular areas to the bases. Do not neglect the lateral aspects of the thorax, still comparing the two sides. Then, listen to the patient anteriorly. If a woman's breast is in the way, move it gently aside or ask the patient to hold it up for you.

Dimensions

You will be listening for (a) the intensity of breath sounds, (b) the type of breath sounds, (c) the duration of the inspiratory and expiratory phases, (d) pitch and timbre, and (e) adventitious sounds. You may find it helpful to review Chapter 4 for help in recording your observations.

Intensity

For the first 10 or 20 chests you examine, just describe the breath sounds as *present;* or if they are locally *absent*, so describe them. If you happen to *notice* breath sounds as *locally decreased*, you may note that also, provided that the decrease is as compared with nature's own control and that you can convince yourself of this on two different passes.

After this time, you may begin to *search* for locally decreased breath sounds, always being careful not to overread slight differences.

Some people have *diffusely decreased breath sounds*, but this statement on your part would mean that you are comparing them, not from one side to the control side, but to the remembered normal distribution of your total clinical experience. Thus, this statement is beyond your competence until you have examined the chests of several dozen people. Diffusely decreased breath sounds may signify restrictive disease, airflow obstruction, or lung distention.

Locally decreased breath sounds result from local airway obstruction, or from interposition of mass between the aerated lung and the stethoscope, such as consolidation or pneumothorax or thickening of the pleural space due to fluid or fibrosis.

For the Advanced Student. The geometry of the airways is not symmetric. Some major bronchi may be directed more posteriorly on the left because of the position of the heart. A study of respiratory sounds and of passively transmitted sounds in normal subjects

showed a right-over-left sound dominance on the upper anterior chest, while breath sounds were louder on the left at the posterior base (Pasterkamp et al., 1997b).

Breath Sounds Audible Without a Stethoscope

Normally, breath sounds become audible without a stethoscope at a distance of 3 ft when the maximum flow rate measured at the mouth exceeds 110 L per minute in expiration and 160 L per minute in inspiration. However, some patients' breathing can be heard at the same distance with flow rates as low as 20 L per minute and 55 L per minute, respectively. This latter phenomenon may be caused by localized stenosis or diffuse narrowing of the large airways, as in chronic bronchitis, asthma, or emphysema. Emphysema may be distinguished from the others in that the inspiratory phase is relatively quiet at the airways (Forgacs, 1969, 1978). Also, see the discussion of stridor below.

With modern technology, breath sounds can be audible at incredibly long distances. A resident, during a wild night on call, discovered that she could hear end-expiratory wheezes by telephone when she asked a worried mother to put the telephone mouthpiece against her child's chest (Karr, 1992).

Breath Sound Intensity Score

The breath sound intensity (BSI) score (Bohadana et al., 1978) was derived as a clinical measure of airflow obstruction, although it may be confounded in subjects with associated restrictive disorders. The BSI is the sum of the scores derived from auscultation in the six zones (upper anterior, midaxillary, and posterior basal chest regions on both sides). Sound intensity is graded as follows: 0 = absent breath sounds; 1 = barely audible; 2 = faint but definitely audible; 3 = normal; and 4 = louder than normal. Two independent observers achieved a correlation of + 0.966 in scores from examining 20 unknown patients at 5-minute intervals ($p < 0.05$). Although the BSI correlates closely with various indices of airflow obstruction (or their logarithms) such as specific conductance, maximal expiratory flow at 50% of vital capacity, and FEV_1 as a percentage of vital capacity, it seems to have been consigned to an ill-deserved obscurity.

Regional breath sounds in emphysema correlate with regional ventilation (Ploysongsang et al., 1982).

Checking Endotracheal Tube Position

When a patient has been intubated, one must immediately ascertain that the tube is properly positioned and not in the esophagus or the main stem bronchus (usually the right main stem bronchus). If the tube is properly placed, when air is blown or squeezed down the tube, both hemithoraces rise freely and symmetrically and then fall freely and evenly with normal free-flow audible breath sounds. If this is done rapidly two or three times (taking just 3 to 4 seconds), the tube is properly located (C. Caine, *personal communication*, 2004).

Be aware that auscultating the chest for symmetric breath sounds while inflating the lungs is not 100% diagnostic. Air in the esophagus may mimic breath sounds in accidental esophageal intubation. Borborygmi elicited by blowing down the tube before the cuff is inflated shows that the tube is in the esophagus. It is also helpful to listen over the *epigastrium* to hear the swish of air that occurs in 90% of cases of such accidental esophageal intubation (Adriani et al., 1988).

Intubation of the main stem bronchus occurred in about 5% of endotracheal tube placements in one study and in as many as 28% of intubations for cardiac arrest. Symmetric breath sounds were reported in 60% (6/10) of such patients and symmetric chest excursion in 70%. It is suggested that mechanical ventilation causes breath sounds to become more bronchial in quality and more readily transmitted to the other side. Also, tube position may change with a change in head position. Listening once is not enough, and routine chest radiographs are indicated to verify tube position (Brunel et al., 1989).

Endobronchial cannulation happens because endotracheal tubes are several inches too long. Dr Curtis Caine of Mississippi cuts them off about an inch above the point at which the catheter for inflating the cuff emerges to the surface. This point is approximately where the tip of the tongue should be when the tube is properly placed. Shortened tubes also have less dead space to be ventilated. A further advantage is that the plastic or metal connector for attaching the tube to the Ambu bag or ventilator, when positioned at the level of the incisors, serves as a bite block so that the patient cannot occlude the artificial airway.

When the cuff is properly inflated (not so tight as to cause ischemia of the tracheal mucosa), by placing your ear close to the patient's mouth, you should be able to hear a slight air leak when the bag is inflated. Check again 5 to 10 minutes after cuff inflation when the air in the cuff has expanded on being warmed to body temperature (C. Caine, *personal communication*, 2004).

To be certain the lungs are being ventilated, monitor end tidal CO_2 and pulse oximetry. An increasing CO_2 level means the lungs are not being ventilated adequately, a low constant CO_2 level means the sample is not from the lungs, and a falling oxygen saturation means inadequate ventilation or oxygenation (C. Caine, *personal communication*, 2004).

Breath Sounds in Trauma Patients

In patients who have suffered a penetrating injury (such as a stab wound or gunshot wound), the finding of absent or diminished breath sounds is a reliable indicator of need for a chest thoracostomy. For diagnosis of hemothorax, pneumothorax, or hemopneumothorax, auscultation had a sensitivity of 58%, a specificity of 98%, an accuracy of 74%, a positive predictive value of 98%, and a negative predictive value of 61%. Reasons for the low sensitivity include inadequate airflow, noisy surroundings, and inadequate training in auscultation (Chen et al., 1997). The first problem shows the value of having the technique of rapid percussion or auscultatory percussion (*vide infra*) in one's diagnostic armamentarium.

Types of Breath Sounds

Vesicular breath sounds and tubular breath sounds are considered in this section. Amphoric breath sounds are really a type of adventitious sound and are therefore considered later.

Vesicular Breath Sounds

Vesicular breath sounds (called "alveolar" by some) are the normal sounds heard over the periphery of the lung fields both

anteriorly and posteriorly. You should listen to your own vesicular breath sounds right now. Vesicular breath sounds are most important when they are not present. Pathologic processes may cause the normal (i.e., vesicular) breath sounds to be replaced by tubular breath sounds, or they may cause the intensity of the breath sounds to decrease or disappear. The specifics of these changes are discussed later. For now, just remember that there are no pathologic processes that can cause vesicular breath sounds to appear where they are normally not present. You need to simply attend to their normal presence or their pathologic absence or diminution.

I do not use any of the fine gradations of vesicular breath sounds (such as bronchovesicular sounds) that you may see in some books, especially old ones. That does not mean that they might not be useful; it just means I have never mastered the technique to that degree.

Tubular Breath Sounds

Tubular breath sounds are also called *tracheal breath sounds* because you can practice hearing them in a normal person by auscultating over the trachea. Some texts call them *bronchial breath sounds*.

A Self-study

When you were listening to the vesicular breath sounds, did you notice that the inspiratory phase is relatively long and pronounced, while the expiratory phase is shorter and almost inaudible? Compare this with the tubular breath sounds over your own trachea, in which both phases of respiration are audible. Repeat the comparison until the difference is very clear in your mind. Have your study partner randomly move the stethoscope head between his trachea and his peripheral chest fields while you listen with closed eyes. Can you reliably hear the difference?

Significance

Tubular breath sounds at the periphery of the lung tell you that there is a solid connection between the lung tissue under your stethoscope all the way to the trachea, a bronchus, or a very large bronchiole. Stated another way, the usual acoustic baffles, the air-filled alveoli, have been replaced by solid matter.

The solid material may be intrinsic consolidation such as a tumor or pneumonia or more extrinsic consolidation such as abnormal lymph nodes. A compressed lung may also conduct sound relatively well. Such compression may result from extrinsic factors such as pleural fluid. There is generally a band of tubular breathing immediately above a pleural effusion (Fig. 16-10A). Very rarely, a thick fibrous scar extending from an air tube out to the periphery can cause a peripheral spot of tubular breathing.

Tubular breathing is mostly white noise originating in the airways. The normal lung acts as a 200-Hz bypass filter so that when the white noise travels through the lung to the chest wall the sound has been changed into what we call *vesicular breath sounds* (Forgacs, 1969). The consolidated lung does not act as a filter but permits all the frequencies to pass (Forgacs, 1969).

Pleural effusions can also produce tubular breath sounds over the entire area of the effusion, not just in a thin band at the top (Fig. 16-10B). In this case, the effusion does not simply float the lung up but compresses it from without to within, as if by a cortex or peel at the periphery. This finding appears in Cabot (1934) but

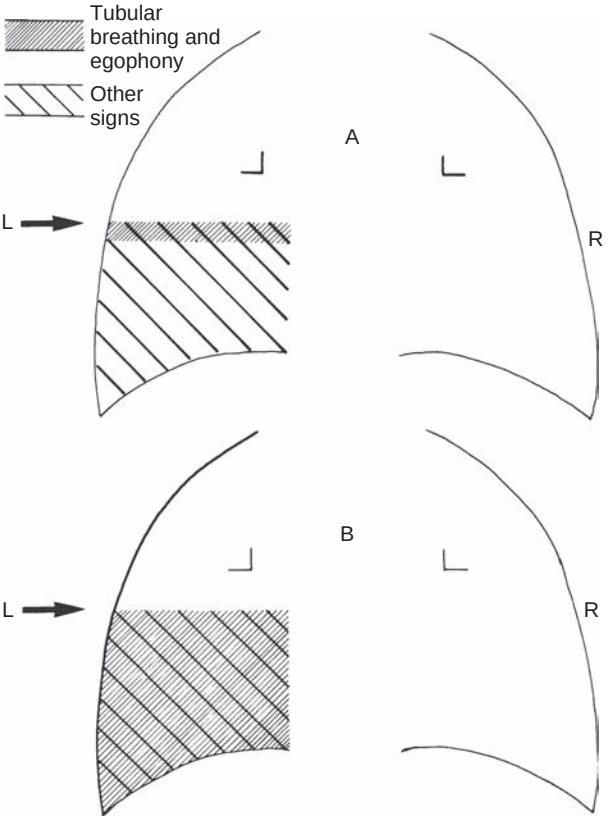

Figure 16-10 Posterior findings of pleural effusion. The *arrows* indicate the upper limit of the pleural effusion. **A:** Tubular breathing and egophony (see text) are heard only at the top of the effusion. If not, this could exactly mimic the findings in the left lower-lobe pulmonary consolidation with an obstructed bronchus. The other signs include inspiratory restriction, decreased tactile fremitus, dullness to percussion, and decreased breath sounds. **B:** A less common pattern. The other signs are as above except that tubular breathing and egophony are heard over the entire effusion.

for some reason dropped out of the textbooks and is unknown to many otherwise well-seasoned clinicians. Cabot noted it especially in thin persons, children, and asthmatics.

One of the d'Espine signs (see later in this chapter) is the only form of tubular breathing intentionally sought not over the periphery of the lung but over a bony structure.

Inspiratory/Expiratory Ratio

There is no doubt that in obstructive lung disease the expiratory phase of respiration can increase relative to the inspiratory phase. But the normal ratio varies with what portion of the lung one is listening to.

Accordingly, before one can be taught a scientific usage of this ratio, one needs to auscultate enough lungs so as to accrue a sufficient experience of the normal. And by that time, one does not need to be taught by anyone. This is why I do not teach this specific ratio.

Pitch, Tonality, and Timbre

Definition

Pitch refers to the predominant note of a musical sound. The physical unit for expressing pitch is cycles per second or Hertz. The higher the frequency, the higher pitched the sound.

Sounds of only one tone, such as those emitted by an oboe, are said to be monotonal. Polytonal sounds may be either musical, as in a harmonica chord (e.g., the sounds made by the several apertures of the mouth organ), or nonmusical (e.g., the breaking of glass). Most lung sounds are actually polytonal but are named for the tone that has the greatest perceived amplitude, such as a "high-pitched wheeze." When the various tones are all of approximately the same amplitude, as in a wheeze or rhonchus, the modal tone is used as a descriptor.

The pitch is not the timbre. Timbre refers to the purity of the sound. An oboe has a pure timbre; a crashing cymbal does not. Some "musical" wheezes have a pure timbre; a pleural rub usually does not.

In the musical score in Fig. 11-4, the pitch is indicated by the note and the timbre is indicated by the instrument for which the note is scored.

Semeiophysiology

To produce a musical sound of a certain frequency, one must vibrate a violin string or a membrane or a column of air at that frequency. Think of the higher-pitched sounds that tend to come from trumpets, and think of the lower-pitched sounds that tend to come from tubas. Some auditors do not realize that a crucial issue in producing a given tone with a brass instrument is the diameter of the mouthpiece, which helps determine the frequency with which the lip will vibrate, the latter determining the pitch of the tone. Thus, it is hard to use your lip to produce an extremely low tone on the trumpet because the relatively small mouthpiece does not permit sufficient excursion of the lip for it to vibrate at a lower frequency. Conversely, it is very difficult to produce high tones on the tuba because the relatively large mouthpiece provides an insufficient support for the lip to vibrate through the small, rapid excursions needed to produce a high-frequency, high-pitched tone. This is different from the situation with other instruments in which the length of the tube determines the pitch of the sound, such as some woodwinds and the pipe organ.

In almost all biologic systems, including the lungs and the heart, the pitch of a sound is related to the frequency of the vibrations at the point of origin of the sound and is specifically not related to the length of the column of air or blood. For instance, the tone of some low-pitched wheezes would require an organ pipe 4 to 8 ft long—obviously a column of air longer than could exist in the human lung (Forgacs, 1978).

For the Very Advanced Student. In his classic article "Crackles and Wheezes," Forgacs (1967) suggested that the pitch of the sounds was related to the mass moved but that the linear velocity of the airstream was more important. The degree to which this latter function is independent of diameter remains unclear to me. Just think of the wind whistling through a cracked window. (Unfortunately, the data were not directly presented, though interested persons were offered an opportunity to listen to tapes of the sounds at the Regional Respiratory Laboratory in London.) But later, in his 1978 paper, Forgacs related the velocity of flow to the intensity of the sound and less so to the pitch.

The physical nature of the acoustic variations found in the percussion and auscultation of the chest have been studied with the aid of the sound spectrograph (McKusick et al., 1955).

Adventitious Sounds

Wheezes

Wheezes are continuous (musical) adventitious lung sounds that last longer than 250 milliseconds. They indicate airway obstruction and can originate from airways of any size. They require sufficient airflow to induce airway oscillations (Loudon and Murphy, 1984). Wheezes should be described in terms of four dimensions: (a) timing, (b) location and place of maximum intensity, (c) pitch, and (d) tonality.

Timing

Wheezes generated within the thorax are more commonly heard in expiration, whereas those generated from the extrathoracic airway may also be heard in inspiration (see the discussion on stridor, below). The degree of bronchial obstruction is correlated with the proportion of the respiratory cycle occupied by a wheeze, but the correlation is not good enough to substitute for spirometry (Meslier et al., 1995).

Expiratory wheezes may be divided into end-expiratory wheezes and holoexpiratory wheezes. End-expiratory wheezes signify bronchiolar disease, either primary (because of structural change) or secondary (as in air trapping). If you exhale with maximum vigor, you may even be able to hear such end-expiratory wheezes in yourself if you generate an intrathoracic end-expiratory pressure that is sufficiently high. In general, expiratory wheezes appear at a peak expiratory flow rate under 50% of the predicted normal; however, holoexpiratory wheezes are associated with a lower peak expiratory flow rate than those that are end-expiratory (Shim and Williams, 1982).

If you hear expiratory wheezes that continue uninterrupted into apparent inspiration, you can say that ventilation in one part of the lung is out of synchrony with that in another part (Forgacs, 1969).

The expiratory wheezes of asthma have the following specific characteristics: If an asthmatic patient reports wheezing, there is a 95% chance that you will be able to hear it. If the patient does not report wheezing, there is still a 30% chance that you will be able to hear it. Expiratory wheezes are less ominous than biphasic (expiratory plus inspiratory) wheezes (Shim and Williams, 1982). The disappearance of wheezes does not necessarily mean that the patient is improving; it may mean that respiratory failure has progressed sufficiently to lower the linear velocity of the airstream below the minimum required for sound production.

Inspiratory wheezes may be divided into holoinspiratory wheezes and end-inspiratory wheezes. Holoinspiratory wheezing, especially of the monotonal type in conjunction with expiratory monotonal wheezing (i.e., biphasic monotonal wheezing), is a sign of rigid stenosis, usually caused by a foreign body, tumor, or fixed scar (Forgacs, 1969), especially when it emanates from high up in the tracheobronchial system (see also the discussion on stridor).

A repetitive end-inspiratory wheeze immediately following some end-inspiratory crackles is almost always diagnostic of a delayed opening of small airways in deflated territories of the lungs.

In hypersensitivity pneumonitis and other pulmonary fibrosing diseases, inspiratory wheezing or "squawking" has been reported (Meslier et al., 1995).

See Table 16.1 for further specific examples of wheezes.

TABLE

16.1 *Classification of wheezes (continuous adventitious lung sounds)*

Type	Tonality			Timing		Location: audible at			
		Polytonal							
	Single	Sync	Async	Insp	Exp	Trachea or mouth	Chest	Presumed cause and site[a]	Specific diseases
1a	+++			++	+	+ +	+	Laryngeal or extrathoracic tracheal *stridor*	Croup, whooping cough neoplasms, polyps, hemangioma, laryngeal web, tracheal stenosis, laryngomalacia, psychogenic stridor
1b	+++			+	++	+ +	+	Functional laryngeal expiratory obstruction	Emotional laryngeal wheezing, factitious asthma
2	+++			+	++	+ +	+	Intrathoracic lobar bronchial obstruction; *fixed monophonic wheeze*	Foreign body, tuberculosis, airway stenosis tracheomalacia or bronchomalacia, airway compression (vascular enlargement or malformation, lymphadenopathy, cysts, neoplasms, dilated esophagus)
3a		+ + +	0		++	++	+	Dynamic compression of lobar bronchi in normals; *expiratory polyphonic wheeze*	Forced expiration in normals, organophosphate poisoning
3b		+ +	+		++	++	+	Dynamic compression of lobar and segmental bronchi in bronchitis; *expiratory polyphonic wheeze*	Asthma
4		0	+++	+	++	++	+	Nonuniform obstruction of several large airways; *random monophonic wheezes*	Asthma
5	+	0	+++	++	+	+	++	Variable airway obstruction in bronchorrheal states; *random "secretory" wheezes*	Organophosphate poisoning, chronic bronchitis, bronchiectasis, cystic fibrosis, interstitial fibrosis
6a		0	+++	+++		+	++	Fixed obstruction of peripheral large airways; *sequential inspiratory wheeze*	Interstitial fibrosis
6b	+	0	+++	+++		+	++	Fixed obstruction of peripheral large airways; *inspiratory "squawk"*	Interstitial fibrosis, hypersensitivity pneumonitis

[a]Italics indicate terms that Forgacs and others have applied to these sounds.
Sync, synchronous; Asyn, asynchronous; Insp, inspiration; Exp, expiration.
+++, almost always; ++, to a greater degree; +, to a lesser degree; 0, almost never.
From Waring WW, Beckerman RC, Hopkins RL. Continuous adventitious lung sounds: Site and method of production and significance. *Semin Respir Med.* 1985;63: 201–209, with permisson.

Location

It seems obvious that the location of the wheeze will be diagnostically useful in that diffuse airway disease will produce wheezes of the same amplitude anteriorly and posteriorly, on the right and the left. This is the situation in asthma, pulmonary emphysema, and any other condition that involves diffuse obstructive airway disease. Conversely, focal obstruction will produce noises radiating from the point of origin (e.g., a peanut aspirated into the left lower-lobe bronchus will make whistles or wheezes loudest on the left, but tracheal stenosis below will make a wheeze that is heard better in the upper center of the chest than peripherally).

A patient was reported to have "diffuse bilateral" wheezing. There were no adventitious sounds other than the wheezes, which were truly bilateral but three times louder at the left base than the right. As the stethoscope was moved cephalad, the lessened amplitude of the wheeze became approximately the same on both sides. What is your diagnosis? (You might want to make a diagram.)

The correct diagnosis is partial obstruction of the left lower-lobe bronchus. This illustrates that wheezes that are "bilateral" in distribution can still be focal in origin, from a point of maximal intensity, and thus not truly "diffuse."

Tracheal Auscultation

In a study of 181 asthmatic patients, wheezes could be better heard by tracheal rather than by chest auscultation in 48% of the patients, whose wheezes could be heard only over the trachea (Waring et al., 1985). (Also see Table 16.1.) The transmission of wheezing sounds through the airway is better than transmission through the chest wall, especially for higher frequency sounds, which are absorbed by the lung parenchyma (Meslier et al., 1995).

Tracheal auscultation is widely accepted as an aid in bronchial challenge tests and in the detection of breath-holding in sleep and nocturnal wheezing (Dalmay et al., 1995).

Pitch

According to Forgacs, no definite conclusion can be drawn about the size of the obstructed airway from the pitch of the wheeze because the velocity of the airflow across the stenosis is of overriding importance.

However, the high-pitched wheeze is likely to signify a fast vibration of air through a relatively narrow orifice (in the same way that the fast vibration is easier through the narrower orifice of the trumpet mouthpiece than through the wider one of the tuba mouthpiece), and thus it is likely to signify bronchiolar and small-airway disease. Diseases of the wider bronchi will tend to give a lower-pitched wheeze, and they also cause less decrease in the peak expiratory flow rate.

Tonality (Monotonal Versus Polytonal)

In the rare circumstances when a monotonal wheeze is truly a single note at its origin, it can be attributed to a single airway brought to the point of closure by stenosis or by expiratory collapse of a single bronchus.

Forgacs expiratory polytonal wheeze is probably the sound that some people call a *sustained harmonic rhonchus*. This is a sign of expiratory collapse of the lobar bronchi in diffuse airway obstruction. But note that any polytonal wheeze may be filtered by the lung so that only one of its tones reaches the chest wall, and it is heard as monotonal.

Assessment of Bronchial Hyperreactivity

The sensitivity of wheezing for the detection of bronchial hyperreactivity is only 50% to 75%. In a methacholine inhalation study in asthmatic adults, wheezing did not occur in some patients even when the FEV_1 had dropped as low as 44% of the baseline value (Pasterkamp et al., 1997a). For detecting a 20% fall in FEV_1, wheezing alone was only 7.4% sensitive, whereas a combination of wheeze detection with a decreased BSI increased sensitivity to 44% (Purohit et al., 1997). Other findings that are more sensitive than wheezing for bronchial hyperresponsiveness include cough, increased respiratory rate, and prolonged expiration (Sprikkelman et al., 1996). Using cough alone as a criterion for asthma can, however, lead to overdiagnosis and overtreatment. Although asthma may present with cough, and cough is a major symptom of exacerbation, different mechanisms are probably involved in producing cough and bronchoconstriction (Chang, 1999).

Keep in mind that wheezing is not pathognomonic for asthma or bronchial hyperreactivity. "Cardiac asthma" owing to heart failure may present in a similar fashion but may require very different treatment.

For detecting chronic airflow obstruction, unforced wheezing has a sensitivity of 15% to 56%, a specificity of 86% to 99%, a positive likelihood ratio (LR) of 6.0, and a nonsignificant negative LR. For detecting asthma, wheezing during methacholine challenge testing has a sensitivity of 44%, a specificity of 93%, a positive LR of 6.0, and a negative LR of 0.6 (McGee, 2001).

Special Types of Wheezes

Stridor

Stridor refers to an inspiratory, expiratory, or continuous monophonic wheeze that is loudest over the central airways. It suggests impending airway obstruction and requires immediate evaluation. Inspiratory stridor usually occurs with extrathoracic airways obstruction and expiratory stridor with intrathoracic obstruction.

The term *stridor* comes from the Latin, meaning a hiss, a whistle, a shriek, or grating or creaking. Thus, bruxism was formerly known as dental stridor, although this term has become obsolete. Stridor now refers exclusively to pulmonary stridor, which is more like a hiss, whistle, or shriek.

If you have not heard stridor, you can imitate it by putting your mouth, lips, and tongue in position to pronounce "ee" as in "see" and then inhaling sharply through your nose to make a loud, high-pitched sound with your larynx or soft palate.

1. *Expiratory stridor* by itself suggests an obstruction in the lower airways or in a bronchus, as with aspiration of a foreign body (such as the fabled pediatric peanut). In the latter, the obstruction occurs when the airflow is maximal and the lumen diameter minimal.
2. *Inspiratory stridor* strongly suggests palatal, tracheal, laryngeal, or epiglottic obstruction (see Chapter 13).

   If there is no one available who is capable of performing a tracheotomy rapidly, be prepared to do a cricothyroidotomy. (For this purpose, you should have a no. 20 scalpel and

TABLE **16.2** *Terminology of adventitious sounds*

Laënnec's French	Late 19th-century English	Usual timing	Late 20th-century English (?)	Robertson's, Coope's, and Forgacs' English
Râle humide ou crepitation	Wet rales, fine crackling rales	Inspiration	Interrupted, high pitched	Crackles
Râle muqueux ou gargouillement (mucoid, gargling)	Gurgling rales ("rhonchi?")	Inspiration	Interrupted, medium pitched	Crackles
Râle sec sonore ou ronflement (snoring)	Low-pitched wheeze (musical) "rhonchus?" (stridor?)	Expiration	Continuous, low pitched; continuous, medium pitched	Wheezes
Râle sibilant sec ou sifflement (hissing)	High-pitched wheeze	Either	Continuous, high pitched	Wheezes

From Forgacs P. Crackles and wheezes. *Lancet.* 1967;2:203–205 and Robertson AJ, Coope R. Rales, rhonchi and Laënnec. *Lancet.* 1957;273(6992):417–423, with permission.

an endotracheal tube in your black bag or at least a large bore needle or two for delivering forced oxygen flow through the cricothyroid membrane.)

3. A patient with a neoplastic obstruction at the tracheal bifurcation will have inspiratory and expiratory wheezing long before he develops true stridor. He will also retain any emphysematous air-trapping sounds in end-expiration if such were present previously. Only when the obstruction is so severe as to maintain increased end-expiratory airway pressure will the air-trapping sounds be lost. At the same time, the wheezes will become the high-pitched inspiratory and expiratory stridor of severe obstruction.

Wheezes in Sleep Apnea (the Shepard Sign)

Sleep apnea syndrome and other upper-airway soft-tissue obstructive syndromes may cause a low-pitched wheeze or vibratory sound (usually expiratory) heard best over the neck. In a series of patients referred for sleep apnea, the sign was found in 50% (Shepard, 1986). Of the sleep apnea patients who had the sign, 85% had it in the supine position while breathing through their noses. However, some had it in other positions or with mouth breathing. (To determine whether the sounds are dependent upon nose breathing, occlude the nostrils, forcing the patient to mouth breathe. Do not simply ask the patient to mouth breathe as some will open their mouths but continue to nose breathe.)

False Positives

The Shepard sign was once heard in a patient with unilateral vocal cord paralysis due to lung cancer. It has also been heard in thin asthmatics. In such patients, it may be a learned response to obstructive disease (i.e., expiratory snoring may serve as an "auto-PEEP").

Rales (Crackles or Discontinuous Adventitious Lung Sounds)

History

Rales were originally described by Hippocrates, who likened them to the sound of boiling vinegar. Note that his definition was more restrictive than the one we use now (*vide infra*). By the 19th century, however, the technique recommended by Hippocrates, applying the ear to the chest wall, had fallen out of favor (Dalmay et al., 1995).

When Laënnec invented the stethoscope, he redescribed rales. (Laënnec admitted that he had read the Hippocratic corpus but stated that he had forgotten about rales. This is undoubtedly an example of what Freud referred to as *cryptogenic*[2] *memory*.) Laënnec now needed to invent a language to communicate his auscultatory findings. He used the generic French term *râles* to refer to any of the abnormal, adventitious chest sounds that he could identify in the first 3 years after he invented the stethoscope. This would be equivalent to the English word "rattle," with its connotations of "death rattle." Because so many of Laënnec's patients (and in fact Laënnec himself) were dying from pulmonary tuberculosis, it was considered unseemly to refer to rales in the patient's presence. Therefore, Laënnec translated rales into the Latin *rhonchus* (a word that can actually be traced all the way back to a Greek word that meant snoring). In the process of translating Laënnec's French and Latin into English, rales began to take on a more restricted meaning, as indicated in the "late 19th-century" column of Table 16.2. Notice that in this scheme the Latin synonym, *rhonchus*, also took on a different, restricted meaning. Although this was not what Laënnec intended, custom has power.

Recently, British auscultators have produced some new terms that seem more physiologically accurate. Forgacs refers to all discontinuous adventitious lung sounds as crackles. These are usually caused by the popping open of air spaces. Table 16.2 should permit physicians of all ages to communicate with each other.

A Note on Pronunciation. The inverted "v" over the "a" in the French word means that the "a" is pronounced as in the English word "palm." Please do not call these sounds "rails." Precision is a useful trait; sloppiness metastasizes.

[2] Cryptogenic memory (meaning "coming from a secret or hidden place") refers to something remembered out of consciousness. Hence, one is not aware that it is a memory, although it is accessible to recall given the right stimulus.

Self-teaching (Majno, 1975)[3]

1. Obtain some very strong vinegar or glacial acetic acid. (Vinegars diluted to 2.5% or 5% will not do.)
2. Heat it in an open pot.
3. Just as it begins to boil, you will hear the sound of rales.

Alternate Teaching Method

Place a lock of hair close to your ear and rub the hairs together. The fine crackling sound is like that of inspiratory rales.

Dimensions and Their Significance

Rales may be described as to timing, location, pitch, amplitude, and repeatability.

1. The *timing* is stated to be inspiratory, expiratory, or both. Wiener and Nathanson (1976–1977) suggested that inspiratory rales be further divided into early and late.

   Early inspiratory rales are said to correlate best with broncho-obstructive disease, while late inspiratory rales are associated with "alveolar" (i.e., restrictive) disease (Forgacs, 1978; Nath and Capel, 1974).

   Early inspiratory rales occurring in chronic bronchitis, asthma, and emphysema generally mean that the FEV_1 expressed as a percentage of vital capacity (FEV_1/VC) is less than 44% (Nath and Capel, 1974).

   Midinspiratory rales are thought to indicate bronchiectasis (Murphy, 1985).

   Late inspiratory rales occur in fibrosing alveolitis, asbestosis, pneumonia, congestive heart failure ("left-sided"), pulmonary sarcoid, scleroderma, rheumatoid lung, and idiopathic pulmonary fibrosis.
2. The *location* of the rales tells you where the abnormality is. Although an area of consolidation with an open bronchus may have inspiratory rales at the top, at the bottom, or all over the area of consolidation, or no rales at all, the rales due to a fixed lesion like pneumonia or interstitial pulmonary fibrosis stay in one place.

   If rales "migrate" to the dependent portion of the lung as the patient changes position, the diagnosis is probably congestive heart failure. Here, the rales are usually *not* the result of intra-alveolar fluid as was once thought but are due to the stiffening of the airways (which now audibly "pop open") from interstitial fluid. The latter is subject to gravity, hence explaining the "migration" (Forgacs, 1967, 1969). Such rales of "hydrostatic" origin, as those of left-sided heart failure, come and go with varying wedge pressure. They tend to appear when the pressure rises above 20 to 25 mm Hg.

   Changes in the location of the rales are important for following a patient's progress. If a sitting patient is admitted for acute congestive heart failure with rales heard all over the posterior thoracic surface and treatment causes the rales subsequently to be present only one third of the way up from the bases, we can presume improvement.

   In patients who have a normal auscultatory examination when upright, rales due to an early or mild pneumonia may be detected by putting them in the lateral decubitus position with the affected lung down and with the arm on the dependent side raised cephalad so that the rib cage is flush against the bed. This position results in partial deflation of the dependent lung. About 19% of normal controls also developed crackles in the dependent lung, but these disappeared after one or two deep breaths, while the crackles persisted in patients with pneumonia. The location of these findings correlate with the site of an infiltrate on the chest radiograph and may precede the appearance of the radiographic abnormality. The findings resolve with appropriate antibiotic treatment (Gilbert, 1989).

   In the lateral decubitus position, patients with pneumonia also sometimes had wheezes or late inspiratory squeaks. A few normal controls had transient, continuous inspiratory sounds like peeling tape. The dependent lung of all subjects exhibited percussion dullness and augmented intensity of the inspiratory phase of the breath sounds (Gilbert, 1989).
3. The empiric rule is that the higher the *pitch*, the more peripheral the lesion producing the rales tends to be.
   a. The significance of high-pitched (fine, as opposed to low-pitched or coarse) inspiratory rales, the most common type, depends partly upon their intrinsic characteristics and partly upon other findings on the chest examination.

      If there are no other findings, isolated fine inspiratory rales usually indicate interstitial edema or pulmonary fibrosis. Bilateral fine crackles were heard in 10% to 12% of patients with COPD, 20% of those with sarcoid and other granulomatous diseases, and 60% of patients with interstitial fibrosis and asbestosis (Epler et al., 1978). (In asbestosis, the rales may even appear before the radiographic changes [Shirai et al., 1981].) I am personally unable to structure a differential diagnosis based solely upon the nature of the fine crackles, although others believe this is possible (Kraman, 1986).
   b. Chronic pulmonary fibrosis sometimes produces a distinct type of low-pitched crackle called "Velcro" *rales*, from the coarse sound made by the Velcro mesh on contemporary sphygmomanometer cuffs. These are not necessarily heard in Hamman–Rich syndrome, whose authors only mentioned "fine and coarse moist rales" but no "Velcro" rales (Hamman and Rich, 1944).
4. The amplitude of rales is often given as a courtesy to other examiners so as to indicate the care required to find the rales. Sometimes amplitude implies the putative significance of the rales (i.e., loud rales are supposedly more important than soft rales). Yet, I could find no scientific data in the literature on significance as a function of amplitude.
5. Furthermore, rales may be described in terms of their *repeatability* (i.e., is the pattern of sounds recurrent or random?). *Random* inspiratory or expiratory rales, crackles, or gurgles may result from liquid in large airways (Nath and Capel, 1974). Recurrent crackles have a visually monotonous pattern of recurrence (as determined by oscilloscopic playback) and are usually auditorially identified by experienced examiners as rales. In fact, this repeatability has been used as evidence for the theory that the sounds come from airways popping open because it would be

[3] Majno's masterwork is recommended for what Osler described as night-table reading. Read it for a few moments of pleasure before you drop off to sleep.

unlikely for bubbles to form and reform in the same manner on successive breaths (Forgacs, 1969).

Air bubbling through fluid, though it might seem to explain the rales of congestive heart failure, could hardly explain the rales that occur in pure lung disease. Many lung diseases (including congestive heart failure) can cause stiffening of the lung tissue so that some of the basal alveoli close at the end of expiration (unlike in normal persons) and thus need to snap open during inspiration. In this instance, the alveoli are said to have a change in their closing volume (i.e., the lung volume at which the contrasting pressures on the alveolus will cause it to close).

Coughing

"Posttussive" rales are rales that persist after cough or voluntary hyperventilation. They are heard in parenchymal infiltrations such as tuberculosis or in interstitial pulmonary edema such as that due to congestive heart failure and so on.

Rales that disappear after cough or intentional hyperventilation may result from a temporary luminal bolus of mucus or "stasis" (i.e., hypoventilation of the base of the lung). This may be caused by chest splinting or loss of the sighing reflex. Such rales are by themselves of no great significance. However, one might still need to explain the cause of the stasis. For example, if splinting is the result of pleuritic pain, one is obligated to explain why the patient is having pain. Sometimes, the explanation is simply abdominal compression of the lower lung fields during sleep, accounting for atelectatic rales present on first awakening.

False Positives

Rales are sometimes a "false-positive" finding in that they have been reported in 0%, 2%, 4.2%, 4.5%, and 14.5% of normal populations (Murphy, 1986; Shirai et al., 1981) in addition to the figures in Table 16.3. Such false positives are usually *not* as numerous (per unit time) as the plethora of crackles occurring almost continuously in pathologic conditions. For instance, these false positives might have but two or three crackles per inspiration. False positives are rarely found when the subject is auscultated posteriorly during normal tidal breathing from the functional residual capacity (FRC) but are more easily found on the anterior basal chest when the subject is breathing slowly and deeply from residual volume (Table 16.3).

TABLE **16.3** *Prevalence of rales in demonstrably normal subjects*

	Anterior (%)	Posterior (%)
Tidal breathing from FRC	0–2	0
Deep breathing from residual volume	43–50	0–7

From Thacker RE, Kraman SS. The prevalence of auscultatory crackles in subjects without lung disease. *Chest.* 1982;81:672–674 and Workum P, Holford SK, Delbono EA, et al. The prevalence and character of crackles (rales) in young women without significant lung disease. *Am Rev Respir Dis.* 1982;126:921–923, with permission.

This no doubt explains the rales heard while rehydrating patients with diabetic ketoacidosis; their hyperventilation causes them to breathe more from their residual volume.

Observer Variability

The interobserver agreement for the presence of rales was 92% in one study in which there was also close agreement between auscultatory findings and sound recordings (Shirai et al., 1981). However, another study showed rather poor agreement ($\kappa = 0.41$, indicating that the agreement was about 41% of the way from the level expected by chance to that of perfect agreement). The results were felt to reflect the fact that basic skills of clinical examination were being poorly taught (Spiteri et al., 1988).

Amphoric Breathing

Amphoric breathing ("jar breathing") is also named *cavernous breathing* because of its diagnostic significance (*vide infra*). Amphoric breathing resembles tracheal breathing in that the two phases (inspiratory and expiratory) are much closer to each other in amplitude and duration than is the case with normal vesicular breathing. However, amphoric breathing has a more resonant and harmonious timbre than tracheal breathing, and its dominant tones tend to be about an octave lower. Furthermore, amphoric breathing is heard where vesicular breath sounds are expected.

A Self-experiment

Obtain a round-bottomed Italian wine bottle of the type that comes wrapped in straw (e.g., a 1956 Orvieto). (Of course, you will need to empty it.) Alternately, a jug or a very large glass or ceramic container with a wide mouth will do. (Remember that *amphora* is the Greek word for a wide-mouthed, round-bottomed jug or a vase.) A large pickle jar, a 1-quart orange juice jar, or even a large peanut butter jar may be satisfactory; a flat-bottomed, narrow-mouthed wine jug is not because the opening is too small and will tend to produce sounds resembling tubular, not amphoric, breathing. The diameter of the opening should be about half the diameter of the base, and the container should be two times as tall as it is wide. Preferably, the bottom should be convex, not flat. These specifications are important for producing the proper sound. Remove the lid and hold the container straight up and down. Bring the proximal lip of the container up against your lower lip and breathe in and out deeply through your own mouth, angling your breath into the jar, rather as if you were playing a flute. As you breathe, listen to the resonance produced inside the container. This is the sound of amphoric breathing.

Next, take some newspaper, old writing paper, fiberglass insulation, or cotton balls and put them in the jar. These represent normal alveoli. Like the normal alveoli, they act as sound baffles.

Repeat the experiment, breathing across the top of the filled container. Note that the amphoric quality of the sounds has disappeared. This illustrates that amphoric breathing is *never* heard in the presence of alveoli or baffles. Thus, amphoric breathing—heard in an area of the lung that is expected to produce vesicular sounds—must be truly cavernous; the sound is of air rushing into and out of a cavity.

Leopold (1952) states that amphoric or cavernous breathingt is normally heard over the occiput, when the subject's mouth is closed, but sometimes a better imitation is produced by having the subject

open his mouth. Leopold also states that cavernous breathing may best be imitated by the whispered word "who." Others prefer the whispered word "war."

Significance

Amphoric breathing always signifies a cavern, hole, cyst, bleb, or other air-containing space in the lung, which is in communication with the bronchial system. While the sensitivity of the sign is unknown, it is 100% diagnostic. Figure 16-11 shows a lesion that produced this sign.

Cavities with relatively rigid and inflexible walls produce the best amphoric breath sounds. A perfectly resilient and deformable cavity, if such a thing could exist, would produce no amphoric (or other) sounds because there would be no way to set up vibrations.

Once a cavity appears and produces amphoric breathing, it should be permanent. Disappearance of a previously noted area of amphoric breathing should suggest that something has now filled the cavity, such as blood, pus, or an aspergilloma.

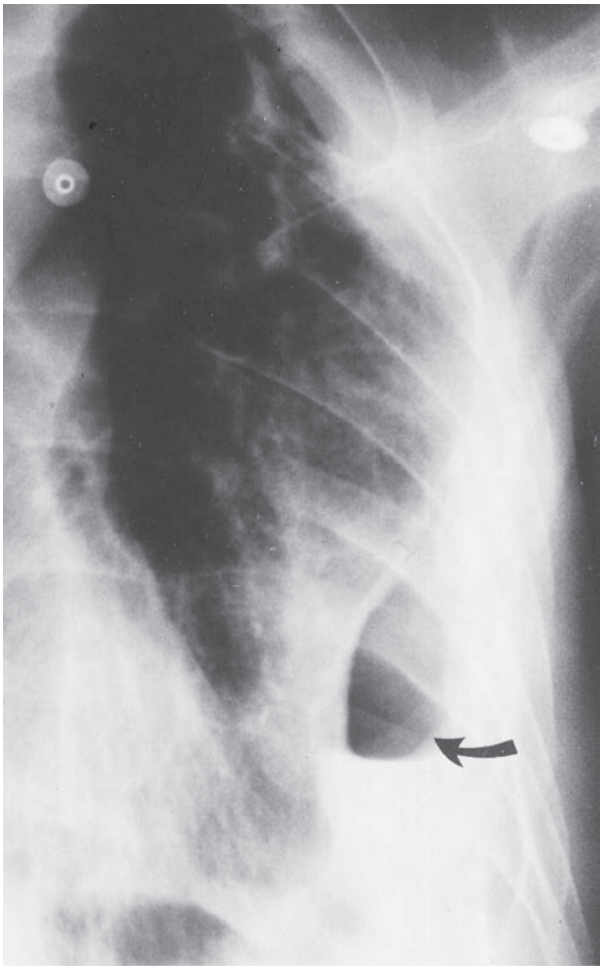

Figure 16-11 Apical lordotic view of the left lung of a patient with a bronchopleural fistula. This film was ordered to investigate the possibility of bilateral apical bullae, which were evidenced by amphoric breathing although they were not seen on two previous PA chest films. The hydropneumothorax (*arrow*) resulting from the bronchopleural fistula (which, oddly enough, was also not seen on the first two films) produced a succussion splash.

Pleural Rubs

A pleural rub is a creaky sound reminiscent of unoiled leather. Classically, it has inspiratory and expiratory components, as one might infer from the fact that it is caused by inflamed visceral and parietal pleural surfaces rubbing *against* each other.

The pleural rub is one of the rare pathognomonic findings in medicine. It always means the presence of pleural inflammation adjacent to the area of the finding. However, it does not tell you whether that inflammation is caused by an adjacent pneumonia, a tuberculous pleurisy, a pulmonary infarct, a tumor, a rheumatic pleural effusion (as in systemic lupus erythematosus), or some other specific etiology.

Pliny the Elder tells us that the artist Apelles did a new line drawing every day of his life (*Nulla die sine linea*, "no day without its line") and would hang each up in his window, lying out of sight so that he could hear passersby give their honest opinions. One day, a shoemaker criticized a drawing because the sandals were rendered badly. The next day, Apelles corrected the error of the sandals and was lying out of sight when the same shoemaker came by. This time, the shoemaker approved of the sandals but now thought that the knee, which he had not previously remarked upon, was awkwardly drawn. This so infuriated Apelles that he leaped up from his hiding place and shouted, "*Ne supra crepidam, sutor judicaret!*" ("Not above the leather should the shoemaker judge!")

This phrase is often mistranslated as "Let the shoemaker stick to his last," even by Robert Burton. It is given here to show that *crepidam* means leather and that a leathery pleural friction rub would be described as crepidant ("creaking like leather"). But rales, which are crackling, are described as crepitant (e.g., see "Crepitus," below). To avoid confusion, let us abandon "crepitant" and "crepidant" and stick with "crackling" and "creaking."

Furthermore, I suggest retaining the "creaking leathery" sound descriptor of pleural friction rubs rather than switching to Forgacs system, in which he refers to them as "crackling intermittent repetitive sounds" (Forgacs, 1969). He objects to the phrase "pleural friction rub" because it involves attributing an etiology to the sound. But the creaking intermittent rub of pleuritis usually sounds quite different from the inspiratory and expiratory sounds produced by a small-airway opening, which Forgacs also describes with the above phrase. Sometimes a more difficult distinction is between the pleural friction rub, which is usually inspiratory and expiratory (but not always; see below), and the polyphonic, medium- to low-pitched wheeze.[4]

If the respiration-associated sound occurs only in expiration or is loudest then, it is probably a polyphonic wheeze (although some wheezes may be heard in inspiration). As a general rule, if the sound is heard only in inspiration, it is probably a rub. Rubs can be heard in both phases but may seem louder in inspiration if the movement of the opposing surfaces is faster.

Another way to distinguish between this wheeze and a rub is to note that the former tends to be transmitted more widely through the chest, whereas the latter is usually more localized. However, some wheezes originating from mucous plugs in

[4]The term "rhonchus," a more apt onomatopoeia for this type of sound, is falling out of favor. Note that this more modern usage of "rhonchus" is not the same as Laënnec's (discussed above).

terminal bronchioles can be quite localized, and pleural disease can sometimes involve large areas.

A third distinguishing characteristic is that the polyphonic wheeze may clear or change with deep breaths and/or vigorous coughing. The rub will almost always persist. Thus, evanescence, if present, diagnoses a wheeze.

Fourth, a clue that can be used by doctors with musical training is the fact that a "descending glissando" tone is diagnostic of a wheeze. The musical tones that make up the sound chord may decrease in pitch as the expiratory sound is made, with all of the tones descending as a harmonic chord. This change in sound frequency can be caused by a change in airflow velocity resulting from the difference in pressure generated in the bronchi during the different phases of expiration. Obviously, the phase of respiration will not affect the musical characteristics of the opposed inflamed pleural surfaces in the case of a pleural rub, so even if the rub had a musical chord, it would not glissade down the scale.

Other Adventitious Sounds

A peculiar series of "pops" can be heard during inspiration over a fractured rib. Sometimes the series of pops can also be heard in expiration. A grating or grinding sound is not always heard despite one's expectation.

Laënnec noted that one could diagnose an intestinal diaphragmatic hernia by auscultating borborygmi above the diaphragm. Nowadays, that finding is more useful for the preoperative diagnosis of diaphragmatic rupture due to trauma (even though the sensitivity is only 7%) (Holm et al., 1988).

The "mediastinal crunch" (the Hamman sign) is caused by pneumomediastinum or by a small left apical pneumothorax (Semple and Lancaster, 1961). It can be spontaneous, be caused by trauma, or be associated with asthma, physical exertion, or forced swallowing. The sound is produced by the touching of the two pleural surfaces with each heartbeat and respiratory excursion, and it usually disappears in the right lateral decubitus position or when more air is injected into the pleural sac. It is not possible to improve on the original description by Hamman, which is reproduced in Chapter 17.

Special Maneuvers

A Note on Definitions

The definitions below (Table 16.4) may sometimes differ from those in other texts. But they are precise and etymologically satisfying.

Bronchophony

Bronchophony literally means "bronchus sound" as it would be heard over the patient's bronchus. Of course, we do not search for bronchophony over the bronchus or trachea. It only becomes a sign (as was the case with tubular breathing, discussed earlier in this chapter) when it is heard in an unusual place.

Both bronchophony and tubular breathing are signs of consolidation with an open bronchus, and so both may be heard over the same area of a diseased lung. However, they are different findings (i.e., the sound in bronchophony is actually produced by the patient's larynx). Bronchial breathing can be detected in a mute, whereas bronchophony cannot.

TABLE **16.4** *Definitions of some signs of consolidation*

Bronchophony	While auscultating remote from the bronchi and larynx, the examiner can hear the speaking patient's laryngeal ("bronchial") sounds, while not being able to distinguish the words.
Pectoriloquy	The examiner can clearly distinguish the word that the patient (a) speaks or (b) whispers.
Egophony	The spoken sound "ee" as in "bee" is heard by the auscultator as the "a" in "bay."

A Method for Eliciting Bronchophony: Teaching Exercise

1. Have your partner say, "Don't overuse the laboratory."[5]
2. Listen over the trachea, then over periphery of the lungs.

Normally, the voice sounds over the lungs are distant and muffled. In a patient with bronchophony, the voice sounds are heard as clearly as when you auscultate over your partner's larynx.

Pectoriloquy

Pectoriloquy literally means "chest speaking." That is, one auscultates the chest and hears speech (i.e., identifiable words, not just sounds [as in broncho*phony*]).

In order to understand words, one must recognize vowels, whose distinction depends upon being able to identify the high-pitched components known as formants. Normally, aerated lungs, acting as a 200-Hz bypass filter, screen out the formants. But solids such as a solid lung, compressed lung, tumor, or lymph node do not. Most examiners check only for whispered pectoriloquy, not for spoken pectoriloquy.

Whispered pectoriloquy is probably the second most sensitive physical finding for consolidation next to egophony, and in some individual cases, it may even be more useful than egophony.

A Method for Whispered Pectoriloquy

1. Have the patient whisper, "Sixty-six whiskeys, please" over and over (see pearl, discussed later in this chapter for an explanation for the choice of this phrase).
2. Listen over the trachea.
3. Now listen over the lung fields and see whether you can find anything that sounds like what you heard over the trachea. (With experience, you can skip step 2.)
4. Call this sign positive only if you are sure about it. One way of testing yourself is to ask the patient to whisper a different number (e.g., his social security number) and see whether you can identify it.

[5] Any sentence can be used.

Egophony ("E to A")

> Egophony resembles pectoriloquy in that it also consists of loud resonance of the voice beneath the stethoscope.... The voice is higher pitched and sharper than the patient's natural voice and has, so to speak, a silvery tone; it produces the illusion that someone is speaking in the patient's chest. It possesses, moreover, one constant characteristic from which it has seemed to me suitable to name the phenomenon; it is quavering and jerky, like the bleating of a goat, and, as may be judged from the foregoing description, it is also similar in timbre to the noise made by that animal. This characteristic is subject to only slight variations, which the reader may picture to himself exactly if he calls to mind the effect produced by a chip placed between the teeth and lips of a person speaking, the sound of the voice when transmitted through a cracked reed, or the stammering nasal tone of a Punch and Judy showman (Laënnec, 1821).

Thus, egophony means "goat sound"; in this case, "ego" comes from the Greek root for "goat," not the Latin for "self." This technique competes with whispered pectoriloquy for the position of most sensitive physical finding for consolidation—if the bronchus is open.

Egophony was independently rediscovered and reported in 1922 by Fröschels and Stocked in Vienna and by Shibley in China. The latter came upon the sign rather accidentally by having his Chinese patients say "i, er, san" (one, two, three). In his province, the word for "one" was pronounced "e." (McKusick et al., 1955).

A Method

1. Instruct the patient, "Say the word 'bee' each time I touch you with my stethoscope."
2. Auscultate over the patient's chest with your stethoscope.
3. If you find a place that sounds like an "a" (as in "ate"), remove your earpieces to be sure that the patient is saying "e."
4. Then plug them back in to verify that you are hearing "a."

Teaching Devices

When listening for egophony, one is listening for a change in timbre, not for a change in pitch. Many students do not initially realize this, and so they miss examples of egophony. An analogy is a trumpet note played with and without a wah-wah mute or a guitar played with a wah-wah pedal. The pitch and amplitude remain the same, but the timbre of the sound is changed.

If you are unable to appreciate egophony in a situation in which someone else can, try the following:

1. Have the other person mark the patient's chest, indicating the area of egophony.
2. Place the *diaphragm* of your stethoscope over that area and have the patient hold it in place. (The air in a lightly applied bell interferes with the phenomenon.)
3. Instruct the patient, "Say the letter ee, as in 'busy bee,' each time I nod" (or "at the same rate I am tapping your arm" if you are behind the patient).
4. Place the stethoscope earpieces in your ears, but keep your hands on them.
5. Start nodding to the patient.
6. After you have heard a number of sounds, quickly pull the earpieces out of your ears on alternate vocalizations. Listen to the differences in the timbre of the sounds, not to the other similarities.
7. Now listen to two vocalizations with the earpieces in your canals and two with the earpieces removed.
8. Once you have identified the goatlike quality of the sound, take the stethoscope head back from the patient, and as he continues to say "ee," auscultate over the area marked for egophony and then over a normal area, comparing the timbre of the sounds. (Over the normal area, the sound is not so different with the earpieces in or out of the ears.)

An Alternate Method

If you do not have a patient with egophony, try listening over the posterior neck or the top of the skull of a normal subject as he says "ee." You may have to look for this artifact in different locations (clavicle, lateral neck, etc.) in different subjects. The sound needs to traverse a path of solid tissue, without interposed alveoli.

After many years of listening for egophony, you will be able to detect a deviation from the "e" that is not quite "a" but is still clearly abnormal although possibly not so to neophytes. (Unfortunately, this useful teaching trick may have contributed to the abandonment of searching for egophony by those who unexpectedly find the sign over the upper chest of normal persons [Sapira, 1995].)

Mechanism

What is the mechanism for egophony? I do not know. One hypothesis is that the "e" sound also has high- and low-frequency harmonics,[6] including an "a" as in "hay." Like all harmonics, they are weaker than the parent tone. However, it happens that solid tissue preferentially absorbs some of the strong primary sound but conducts the harmonics better, thus unmasking them. (This works only in the special case of "e" to "a." In the converse case, if the patient says "a," it will not sound like "e.")

One might object to this mechanism because the solid tissue of the chest wall obviously does not have the effect of converting an "e" to a goat sound. The difference is that the chest wall is not directly connected to the resonator (the vocal cords), while the neck tissue and the consolidated lung are so connected. While this explanation may be invalid, the following observation certainly holds: No matter how fat the body wall, it does not convert "e" to "a," whereas if even a little underlying lung is compressed by a pleural effusion, the goat sound appears.

Summary. The production of egophony requires that the diaphragm of the stethoscope be connected through a bridge of solid tissue (such as a consolidated lung) to the resonator (the vocal cords).

Occurrence (with a Note on Epistemology)

Texts on physical diagnosis agree that egophony may be present at the top of a pleural effusion. However, it is not commonly appreciated that in addition to this thin disk of egophony at the top of a pleural effusion (supposedly because of the upward compression of the lung parenchyma by the underlying fluid), thin persons and young persons with massive pleural effusion may even have egophony over the entire area, as first noted by Laënnec.

[6] These "harmonics" may not be of pitch but rather may be the Fourier waves other than frequency. The postulated "absorption" of the primary wave forms by solid tissue may be a sympathetic resonance, explaining why fluid never produces egophony until it compresses lung tissue.

Presumably, this is the result of circumferential lung compression (Cabot, 1934).

Texts are uncertain as to whether egophony is also present over an area of consolidation. Some vote in the affirmative, some in the negative, and some are in the cloakroom. The latter two conclusions stem from a lack of awareness that the patency of the bronchus and bronchioles leading to the area of consolidation will influence the outcome of the test. If the bronchus is patent (and thus connected to the resonator), egophony will appear. If the bronchus is obstructed (and the area of consolidation is disconnected from the resonator), there will not be egophony.

This issue should have already been unanimously decided by experience and thus illustrates the importance of enlightened skepticism in the thinking of the excellent physician. You should not trust every book wholeheartedly. You should read them, of course, because it would be impossible to recreate the entire medical experience by yourself, as Hippocrates implied when he wrote: "The art is long, but life is short." However, you should remember the less-quoted phrase that Hippocrates added to that aphorism: "Experience is deceiving." To believe everything you read with no qualifications is to indulge in the Myth of Infallibility: All physicians make mistakes; the excellent physician is the one who is corrigible.

Papers on laboratory medicine begin with a section entitled "Materials and Methods," which is intended to permit any other member of the scientific brotherhood to replicate the experiments, were he so inclined. The beauty of physical diagnosis is that the tools for replicating the statements of others are not those of an arcane exotic technology, accessible only to a well-funded few, but are the contents of your little black bag. Thus, physical diagnosis should be the most scientific of the disciplines. Alas, it usually is not.

False Positives

An important "false-positive" cause of egophony is fibrosis of the lung parenchyma in the absence of pleural effusion or parenchymal consolidation. This fibrosis may appear on chest radiographs as fibrous "stranding," especially the kind radiating out from the hilum as in patients with chronic obstructive and restrictive disease. Here, the egophony seems to result from the selective conduction of harmonics through the fibrous tissue. The physical findings may enable one to predict the chest radiography when the egophony is bilateral and spotty but so extensive that parenchymal consolidation cannot be the explanation because the patient would in that case be more breathless. Furthermore, other signs of parenchymal consolidation (except, rarely, tubular breathing) do not occur over such areas of egophony.

A spot of isolated egophony (i.e., unaccompanied by other signs of parenchymal consolidation) was once found over what I thought to be an azygos vein on the chest radiography. A computed tomography (CT) scan showed this to be a tortuous brachiocephalic (innominate) artery, which apparently was compressing some lung tissue.

A True Negative

On one occasion, it was possible to diagnose what the radiologist had called a *pleural effusion* as actually being pleural thickening (fibrosis)—even though the trachea was not shifted. How? There was absolutely no egophony anywhere near the area of percussive dullness and decreased breath sounds.

Because it was impossible to get the "fluid" to shift, no matter what position the radiologist put the patient in, further expensive procedures were planned to obtain a sample of the "fluid." The diagnosis of pleural thickening was not accepted at first because of the difficulty in explaining how the patient's prior upper thoracic stab wounds could have produced a lower thoracic pleural fibrosis. However, an interview revealed that a chest tube had been placed in the lower thorax in the exact area of the pleural fibrosis.

The moral of that story is not that the interview should precede the physical examination (of course, it should) but that pleural effusion and pleural fibrosis can sometimes be distinguished by the fact that the former should compress the lung somewhere and so produce an area of egophony, while pleural fibrosis and thickening may well not compress any lung tissue and will therefore show no egophony.

The d'Espine Sign

Introduction

Several signs heard over the vertebral bodies (C-7, T-1, and lower), in cases of a solid lesion in the posterior mediastinum, were described by d'Espine. These include whispered bronchophony, bronchophony, and tubular breathing. The last was handed down by oral tradition at the University of Pittsburgh around 1960; I learned it at the bedside from Dr Eugene D. Robin of California.

A Method

Compare the intensity of the breath sounds as heard over the vertebral column with the intensity of the sounds at the same level as heard to the right and left of the vertebral column. Normally, the vesicular breath sounds coming from the right and left lung are louder than the sounds heard over the vertebral body at the same level (Fig. 16-12A).

If the sounds over the vertebral body are louder, and actually tubular in quality, the d'Espine sign is positive (Fig. 16-12B).

d'Espine considered the sign to be positive if heard over the seventh cervical vertebra (C-7) or more caudad. C-7 is called the *vertebra prominens* (see Fig. 8-3) because of its relatively long and easily felt nonbifid spine. It is the first clearly palpable spine on running one's fingers down along the vertebral crests, although the spine of T-1, immediately below it, is actually the most prominent one. However, d'Espine originally described his sign in children, whose anatomy is somewhat different from that of adults. In adults, one should listen for the sign much lower, down around T-4 and the region where the trachea bifurcates. The further caudad, the more likely a positive sign is to be significant. The more cephalad one listens, the more likely the sign is to appear as a false positive, probably for reasons similar to those that can produce egophony near the neck of many normal persons (*supra*). (Being "too cephalad," by the way, does not explain the false positive given below.)

Interpretation

A positive d'Espine sign implies that the posterior mediastinum, a roentgenographically silent portion of the chest on the PA film, contains a solid lesion connecting the tracheobronchial system with the vertebral body. Currently, the most common causes of the solid lesions are lymph nodes (lymphoma, sarcoid, metastatic malignancy, and the historic prototype tuberculosis, much less common now)

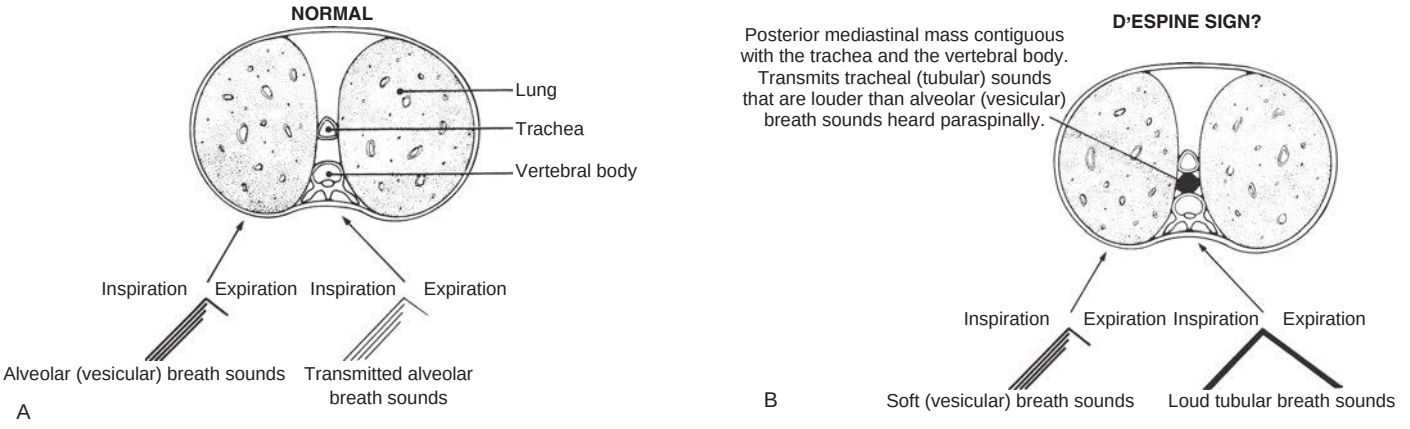

FIGURE 16-12 **A:** Normal auscultatory findings over chest and vertebral bodies. In a quiet room, one can sometimes hear alveolar breath sounds of the juxtavertebral lung softly radiating to the vertebral body. **B:** d'Espine sign? In the presence of a posterior mediastinal mass contiguous with the trachea and vertebral body, auscultation over the vertebral body reveals transmitted tracheal (tubular) breath sounds that are louder than the vesicular breath sounds radiating from the lung on either side. (Although shown for the trachea, the same phenomenon could occur with the bronchi or even very large bronchioles, provided that some tumor mass or other solid material provided contiguity between the tubes and the vertebral body.) The question mark indicates that there are actually two other d'Espine signs. But the others (see text) are so overly sensitive that they generate too many false positives. Thus, perhaps the tubular breathing d'Espine sign shown here should be the only sign of that name.

or tumors, with or without supplementary auscultatory conduction from lymph node metastases. The most common tumor is bronchogenic carcinoma.

False Positives

A false-positive d'Espine sign occurred in a patient with kyphoscoliosis. Tubular breath sounds were heard over the vertebral column. This patient also had a lung tumor (not in the posterior mediastinum), pleural effusion, and an ectatic aorta. But according to the CT scan, there was no tumor or lymph nodes in the posterior mediastinum. Part of his tracheobronchial system was applied to the aorta, which was tightly pressed against the kyphoscoliotic vertebral column.

This case was very puzzling. Although one can blame the kyphoscoliosis for producing an abnormal contiguity of the trachea, aortic arch, and vertebral body (above T-5), normally the d'Espine sign is not present below T-5, where the left main stem bronchus lies against the aorta, which in turn seems to be sufficiently close to the vertebral body (Ledley et al., 1977) to produce a false positive. Perhaps the key lies in the word "sufficiently." In any event, this is an example of the interesting kind of puzzle that disrupts tedium for the thoughtful practicing physician and involves available technology (the stethoscope).

A unilateral false-positive d'Espine sign occurred in a patient with intrathoracic tracheal deviation. Tubular breath sounds were heard in the interscapular space on the side of the vertebral column containing the trachea. The sounds were heard less well over the vertebral column but better there than over the contralateral side of the chest. On examination of the CT scan, it became apparent that the cause was simply tracheal malposition.

A peculiar false positive occurred in expiration only in a patient who swallowed air and maintained an air esophogram on his lateral chest film. It is assumed that the air in the esophagus was squeezed into motion during expiration, thus producing the tubular breath sound.

Two Additional d'Espine Signs

The pathophysiology of the finding described above should suggest that other acoustic phenomena, which are based on the transmission of sound through a solid, might also be manifested over the vertebral column in case of a solid lesion in the posterior mediastinum. However, this never occurred to me, and on getting d'Espine's original papers, I was surprised to learn that he had described several signs heard over the vertebral bodies (whispered bronchophony, bronchophony, and tubular breathing) of which tubular breathing was the least sensitive. His own description is as follows:

> The best signs of bronchial adenopathy are exclusively furnished by auscultation of the voice sounds and are almost always found in the immediate vicinity of the vertebral column between the seventh cervical vertebra and the uppermost thoracic vertebrae .... There is a change given to the voice which is called whispering[7] in the first stage and bronchophony in the more advanced stage.
>
> To these signs there is added, when the lesion is more obvious, the bronchial murmur (bronchial or tubular breathing) which extends through both phases of respiration, the intensity varying accordingly in these cases (d'Espine, 1904).
>
> Following the advice of Professor Lasegue, we have them say, as distinctly as possible, the number trois cent trente-trois (333)... (d'Espine, 1907).

Caveats

1. Call these other signs positive only if you are sure.
2. As was the case with the word "99" in searching for tactile fremitus, Lasegue's instructions should not be translated literally. The number "333" in French contains a whispering sound. So this is simply Lasegue's clever trick of getting spoken words and sibilant whispers into the same signal so as to be able to do bronchophony and whispered

[7] d'Espine's *chuchotement*.

and spoken pectoriloquy at the same time. To get the same effect in English, have the patient say "66 whiskeys, please," not "333."

For the Attending. In preparing this, I originally wrote that I could not find the d'Espine sign in any book. Later, I found all the signs mentioned in my medical school textbook of pediatrics, the seventh edition of Nelson. My notes show that I read the passage on at least three different occasions but apparently ignored it, perhaps because the author of the passage described the signs as "not discriminating" or because pediatricians seemed to be less impressive physical diagnosticians than the internists I had observed. (Or perhaps because the index of this edition of Nelson contains the entry, "Birds, for the," followed by the book's inclusive pagination, apparently a Parthian shot[8] fired by the indexer, who was rumored to be Nelson's son-in-law dragooned into a noxious service.) Whatever the cause, there are two principles elucidated here: First, scholarship must be thorough because memory is faulty, and second, one good bedside demonstration is worth three readings of a textbook.

Auscultatory Percussion

Auscultatory percussion was originally described by Laënnec and was used to outline various solid organs (Norris and Landis, 1938). The stethoscope was placed upon the part to be investigated, and the examiner listened while percussing from the periphery toward the chest piece. The sounds became distinctly louder when the boundary of the organ was reached.

The principle of auscultatory percussion was developed for the detection of heart size, liver size, spleen size, kidney size, bone fractures, ascites, and pleural effusion (Cammann and Clark, 1840) but seems to have been lost. There seems to be no recognition of the common history by authors who appear to have rediscovered the technique on their own (for instance, see Webb's 1927 utilization of the technique for pleural effusion in Appendix 16-1; the various "scratch" tests for cardiac and hepatic size [see Chapters 17 and 20]; the "puddle sign" of ascites [Chapter 20]; and the Gairdner coin test [see below]).

In the modern era, Guarino developed auscultatory percussion techniques for the chest (Guarino, 1974), as well as for the skull, urinary bladder, and abdomen (see Chapter 20). Using polyurethane models of the thorax, he claimed that the technique could locate small deep parenchymal masses (Guarino, *personal communication*, 1988). Guarino's original method, which is described below as is his later method, was designed to look specifically for pleural effusions.

A Method

1. With the patient sitting or standing, percuss directly over the manubrium by tapping *lightly* with a fingertip. (The rationale given for striking the manubrium was to avoid "the interfering effects of the left ventricle," especially when the latter is enlarged [Guarino, *personal communication*, 1987].)
2. Auscultate the tapping sound by placing the stethoscope diaphragm on the posterior thorax; compare the sounds on the two sides, moving from top to bottom, no more than the diameter of the diaphragm each time.
3. Dr Guarino reminds us to complete the examination by placing the diaphragm piece on opposite sides of the spinal column to detect hilar and mediastinal lesions (*personal communication*, 1984). Take care not to overread the changes (Fig. 16-13).

For the Attending. When learning and teaching auscultatory percussion, I strongly recommend that the maneuver be subjected to the most critical scientific scrutiny. I do this by having the student auscultate posteriorly while I tap on the chest anteriorly with my eyes closed so that I cannot know which side of the chest the student is auscultating. It is very easy to unconsciously modify the intensity of the blow; in fact, it is very difficult to strike exactly the same blow every time. Accordingly, one must be especially aware of the observer effect (the unconscious tendency for the observer to produce the effect he desires).

Musicians who play percussion instruments must be particularly careful to have their finger strike through an excursion of the same distance and force each time. (Many percussion instrument players adjust their hand stroke to produce a constant sound intensity without being aware of it!)

Interpretation. A lesion is said, by Guarino, to cause an area of dullness "like casting a shadow."

Comments. Guarino's results were extremely impressive and did much to reawaken interest in this technique. In a series of 30 patients with varying abnormalities of the lung, mediastinum, or pleura but negative or equivocal findings on conventional percussion, he claimed a sensitivity of 0.96. He was able to detect smaller lesions (e.g., a 1.5-cm pulmonary nodule) than can be detected by conventional physical examination (Guarino, 1980).

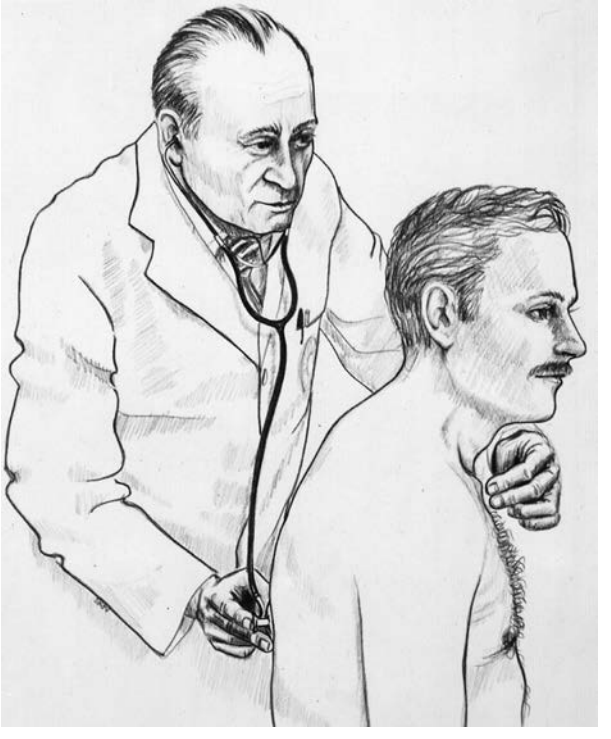

Figure 16-13 Auscultatory percussion of the chest. (Courtesy of Dr J. Guarino of Idaho, with permission.)

[8] The Parthian cavalry were known for suddenly wheeling and shooting arrows back at the adversary from whom they had been pretending to flee.

Self-test. What was the specificity of auscultatory percussion in Guarino's 1980 study? (Answer is in Appendix 16.2.)

Guarino thought that the sound waves traveled through the lungs and that findings were caused by transmission of sound from material with low acoustic impedance (air or gas) to one of high acoustic impedance (water or body fluids). This theory has been challenged; after all, the technique does not "find" the heart but does find the Grocco triangle. Others think the findings are explained by the differences in cage resonance induced by underlying abnormalities (McGee, 1995). Audio recordings in normal volunteers who breathed in air and an 80%-helium–20%-oxygen mixture and performed the Mueller and Valsalva maneuvers (which subject the chest wall to stiffening forces) were consistent with the latter theory: "The chest wall… behaved as a resonant cavity, partially damped by the thoracic contents" (Bohadana and Kraman, 1989). This hypothesis was supported by the results of using recordings at various points on the thorax to construct three-dimensional contour maps of the amplitude of sound transmitted from sternal percussion (Bohadana et al., 1989).

Others have had less success with Guarino's method (Bohadana et al., 1986; McGee, 1995; Yernault and Bohadana, 1995). Auscultatory percussion was found to have a sensitivity of 15%, 19%, or 86% in different studies, compared with 9%, 15%, or 76%, respectively, for conventional percussion. In the same studies, the specificity was 88%, 85%, and 84% for auscultatory percussion and was 99%, 97%, and 100% for conventional percussion. For auscultatory percussion, the predictive value of a positive test was as low as 31% in one study in which the number of lungs with positive findings by this technique was only 16 (Bourke et al., 1989).

Auscultatory percussion was most successful in detecting large pleural effusions (sensitivity = 0.71) or lesions such as pneumonia or pulmonary infarcts that were in close contact with the chest wall.

In a study of patients seropositive for the human immunodeficiency virus (HIV), Guarino's technique of auscultatory percussion was found to be more sensitive than conventional auscultation or percussion for all three examiners, a third-year medical student, an intern, and an attending physician (sensitivity ranging from 51% to 70%). Chest radiographs were abnormal in 55.6% of the test population, with findings heavily weighted toward interstitial lung disease. The combination of auscultation and auscultatory percussion detected 31 more abnormalities than did the combination of auscultation and conventional percussion. Auscultation was restricted to breath sounds only; egophony or whispered pectoriloquy were not sought (Nelson et al., 1994).

Guarino's Second Method for Pleural Effusions

1. Have the patient sit up for at least 5 minutes to permit pleural fluid to gravitate to the base of the lung.
2. Place the diaphragm of the stethoscope posteriorly with its upper edge about 3 cm below the last rib in the midclavicular line.
3. Apply direct percussion with the free hand, preferably by finger flicking or with the pulp of the finger, along three or more parallel lines from the apex of each hemithorax perpendicularly down toward the base (Fig. 16-14).

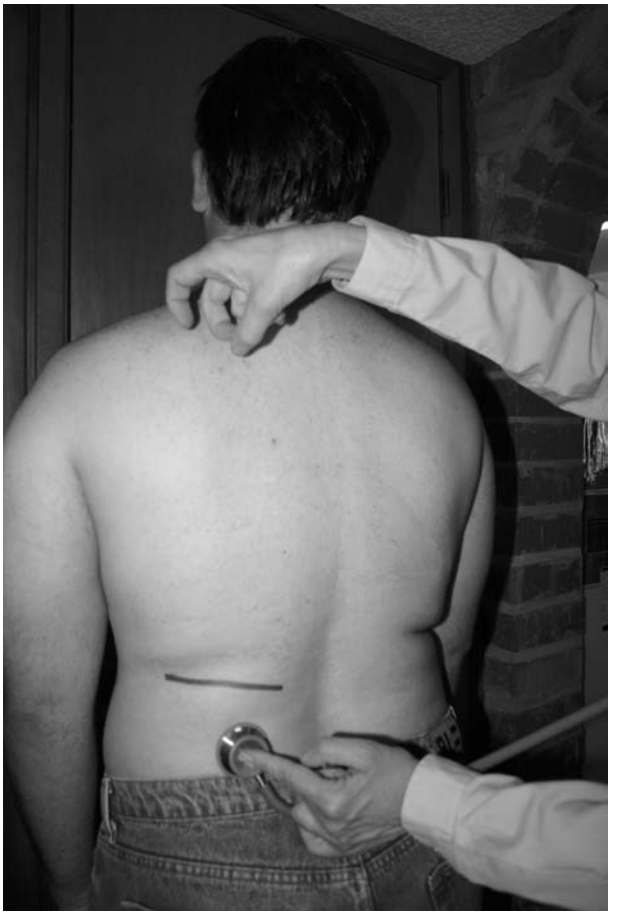

Figure 16-14 Guarino's second method of auscultatory percussion. (Photograph by Patti Wylie, with permission.)

Findings

Normally, the percussion note perceived through the stethoscope sounds dull, changing sharply to a loud note upon striking the last rib. In the presence of a pleural effusion, a similar change occurs at the interface of an air-containing lung and pleural fluid, with the level being higher laterally. On the side opposite an effusion, the change occurs on the border of Grocco triangle. A shift in fluid level with lateral tilt can help distinguish a subpulmonic effusion from a raised hemidiaphragm. A shift in level downward with forward tilt and upward with backward tilt is also said to occur.

To avoid false positives, it is essential to mark the last rib and keep the diaphragm of the stethoscope well below this rib.

A sensitivity of 96% and specificity of 100% is claimed. As little as 50 cc of fluid was detected with this method, whereas an accumulation of 300 to 500 cc may be required before a level is seen on an upright radiograph because it is obscured by the hemidiaphragm (Guarino and Guarino, 1994). Others have not been able to match these results. In various studies, the positive LR for pleural effusion has ranged from Guarino's 19 down to 1.0, with a pooled value of 7.7, and the negative LR from Guarino's 0.05 to 1.0, with a pooled value of 0.27 (Wong et al., 2009).

A Note for the Student. With auscultatory percussion as with other techniques, it is possible that less successful examiners were using faulty techniques or were unpracticed in interpreting the

findings. All students, including seasoned clinicians, should check the examination both before and after looking at the radiograph in order to improve their skills.

The Coin Test

The coin test is a variant of percussive auscultation and is diagnostic of pneumothorax or a giant bulla (Fig. 16-15).

A Method

1. The patient holds a silver dollar (pure or alloyed) flat against the anterior hemithorax, under the clavicle, and around the third interspace in the midclavicular line.
2. Auscultate with your stethoscope posteriorly while striking the flat silver dollar with the edge of another silver dollar.
3. Repeat the test with the coin and stethoscope placed on the other hemithorax.

Normally, the auscultated sound is dull and tapping. Over the side of the pneumothorax, one hears a distinctly different sound that seems louder, more clicking, and more ringing, apparently because of the loss of sound muffling from the intervening lung, whose alveoli no longer act as anechoic baffles. This finding should, of course, be on the same side as the other physical findings although the coin test works even with pneumothoraces so small as to give no difference even to percussion.

A Caveat. Unfortunately, the coin test does not work with pennies, nickels, dimes, or quarters because they are too small to make enough of a "ringing" noise. A pair of Mexican 20 peso coins is a satisfactory substitute for silver dollars but both are increasingly difficult to find.

A Self-study

It is fairly easy to hear the normal sound of the coin test by practicing on one's partner. However, therapy for pneumothorax is instituted so quickly nowadays that most medical students do not have the opportunity to practice on a patient. The closest one can come to the sound of the coin test on the side with pneumothorax is by puffing out one's cheeks with the mouth closed and the jaws open and then having one's partner hold the stethoscope over one cheek, while one percusses the coins over the other cheek. Compare this "pneumothorax" sound to the sound of the coin striking when performed over the student's (presumably normal) lung.

Figure 16-15 The coin test. (Photograph by Patti Wylie, with permission.)

To pick up very small pneumothoraces, it is necessary to auscultate over the supraclavicular fossae while percussing posteriorly high in the interscapular spaces. The smallest pneumothorax I have ever detected is shown in Fig. 16-16.

Using the coin test for the first time, a naive medical student was also able to demonstrate this pneumothorax.

False positives may rarely occur over an area of subcutaneous emphysema. Air in the esophagus, as in achalasia, may cause a peculiar false-positive test only in the sternal region.

False negatives may occur. Normally, a pneumothorax results in a circumferential replacement of lung tissue by air. Thus, when we look at the pneumothorax in Fig. 16-16, we are looking at only a part of it, at a lateral tangent or chord through the rind that actually extends in front of and behind the central lung, which is still inflated. It is through this rind or outer corridor of air that the ringing coin sounds, not directly from front to back. Thus, if the pneumothorax is loculated by prior pleural adhesions, it might, if it is in the midaxillary line, be easily visible on X-ray but may not be delectable by the coin test because there would be no peripheral semicircular corridor of air to carry the ringing sound. Recently, such a patient with a hydropneumothorax approximately 10 cm in height and 3 cm in the transverse dimension was seen (Fig. 16-11). The hydropneumothorax was only in the left axillary line, and so it was negative by the coin test.

Another false negative was found in a patient with bilateral apical pneumothoraces, who had known bilateral apical bullae. Here, the ringing sound was attributed to the bullae, there being no "normal" side for comparison. The fact that the radiologists had just as much trouble (three of them sequentially reading the

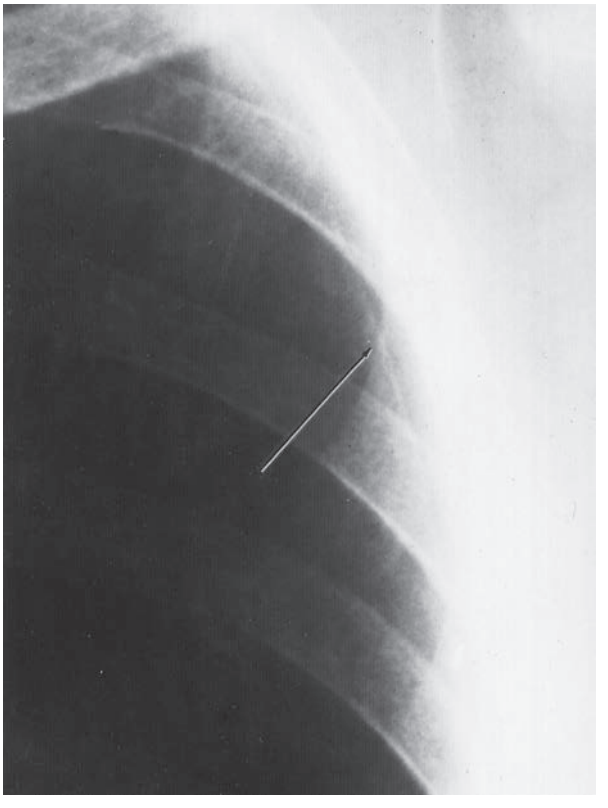

Figure 16-16 Small pneumothorax, detected on physical examination by the coin test.

same films as "bilateral bullae, no pneumothorax," "bilateral apical pneumothoraces," and "left pneumothorax") holds no consolation and only illustrates principle that chest films are best interpreted by the person who has examined the patient.

False negatives may result from improper examining techniques. As noted previously, one should never examine the chest for acoustic phenomena with the patient recumbent on the bed or examining table. With this test, the bedding may muffle the ringing of the coin sufficiently to make the distinction between the two sides too subtle for confident diagnosis.

For the Very Advanced Student. While auscultatory percussion works with the thumping of chests, the ringing of coins, the flicking of flanks (see Chapter 20), and even the scratching of tissue (see Chapters 17 and 20), it does not work with a tuning fork. Michelson reviews the trials of the latter technique, some arguably successful (Michelson, 1926).

The Succussion Splash

Whenever there is a large body of fluid contained beneath a gas, there is a surface that can be made to splash by shaking the container. This is called the *succussion splash*, and it can potentially detect any cavity that contains an air–fluid level.

A Method

Originally, Hippocrates tested for the succussion splash by placing his ear up against the patient's body and shaking him. Now, we have the aesthetically superior device of the stethoscope, but we still must vigorously shake the patient's body to produce the splash. This can be difficult because one needs one hand to hold the stethoscope to the chest (or abdomen) and two more hands to shake the patient. Thus, if you cannot get someone to assist you by holding your stethoscope in place, you may have to revert to the Hippocratic method of placing your ear against the part of the patient's body that you are shaking.

Teaching Trick

Cabot used the following teaching trick to make the point that there must be a gas–liquid border to produce a succussion splash. He had the students fill a hot water bottle full to the top so that there was no air. One could shake it very vigorously and still not produce a splash. He then had the students empty the hot water bottle halfway and allow air to fill the remainder of the chamber before restoppering it. Shaking the bottle would now produce an excellent imitation of the succussion splash.

This exercise can also be used to illustrate how hard one must shake the bottle (and hence the patient) to produce the splash.

Significance

In the chest, a succussion splash is found in hydropneumothorax (Fig. 16-11) or, rarely, in hemopneumothorax. It might be thought that a lung abscess would produce a succussion splash but it almost never does, probably because the pus is so thick that it will not splash, or perhaps because the gas–liquid phase border is too far from the ear or the stethoscope.

The succussion splash is also used to identify air–fluid levels in the abdomen as in gastric outlet obstruction (see Chapter 20). In the thorax, it may be found with achalasia (Sullivan, 1990).

The succussion splash was abandoned for a time because Hippocrates stated it to be useful in empyema, although it most decidedly is not unless the empyema results from gas-forming bacteria. It was revived as a test of hydropneumothorax by Laënnec.

Forced Expiratory Time

A Method

A simple test for airway obstruction is the clinical forced expiratory time (Lal et al., 1964).

1. Place the bell of the stethoscope over the trachea in the suprasternal notch and set your stopwatch to zero.
2. Instruct the patient to take in the deepest breath possible and then blow it all out, "as fast as you can."
3. As the patient begins to exhale, start the stopwatch.
4. As soon as you no longer hear audible expiration, turn the stopwatch off.

Interpretation

A value greater than 6 seconds suggests airway obstruction. The clinical forced expiratory time correlated extremely well with the forced expiratory time measured by spirometry, the latter being almost 1 second greater, on the average (Lal et al., 1964).

Comment

The original authors suggested using three trials and then averaging the results.

Breath-holding prior to expiration is not obligatory but rather a convenience for those examiners who use sweep–second-hand wristwatches instead of stopwatches. Such examiners must often wait for the second hand to reach a starting point.

Alternate Method

I have also seen this test performed by listening over the posterior superior thorax. If expiratory sounds were heard for more than 3 seconds after the beginning of visible expiration, the test was considered positive as a screen for obstructive pulmonary disease.

Also, see the match test (discussed later in the section on Findings of Emphysema).

Spirometry

Hutchison was the first to apply the measurement of lung volume to diagnosis. He compiled measurements in more than 1,200 young men and produced a predictive equation of lung volume by height. He was unable to acquire comparable data for women "in consequence of their strange costume preventing so free a movement of the parieties" (Warren and Warren, 1997). In 1866, Salter hooked the spirometer to a kymograph producing volume/time graphs, with the great advantage of objectivity:

> But they will have a certainty and a positiveness that no interpretation on the part of the observer can possibly have… It will be like a photograph of Breathing. The lines will not be "doctored" whatever the patient may be. There will be no disputing them; it will be impossible to say that they are the result of imagination or error (Warren and Warren, 1997).

Nonetheless, spirometry did not come into common bedside use until a century later. At present, peak expiratory flowmeters are commonly used in frequent monitoring of asthmatics; patients can purchase such a device on the Internet for around $20. Spirometry is now considered the gold standard for diagnosing chronic obstructive lung disease and emphysema (see below).

Synthesis

Review of Principles

The Two Principles of Chest Inspection

1. The chest normally expands with inspiration. This principle will help you identify the diseased side, in cases of unilateral disease.
2. The negative inspiratory intrapleural pressure on each side is like two hands tugging equally on a wishbone. It keeps the trachea in the midline. Therefore, loss of the inspiratory negative intrapleural pressure on one side, as in pneumothorax, will permit the healthy side to win the tug-of-war. Similarly, an effusion will push the trachea to the healthy side. But scarring and atelectasis will pull the trachea toward the afflicted side.

The Two Principles of Chest Palpation

1. Solid substances (like a consolidated lung) transmit sound vibrations better than substances filled with air (like a normal lung).
2. If you want to feel the loudspeaker vibrate when you put your hand on the radio, do not wear insulated mittens. (Tactile fremitus is decreased by anything that acoustically insulates your hand, such as a pleural effusion or thickening.)

The Two Principles of Chest Percussion

1. Drums boom but thighs thud. This means that the normal resonant lung will boom when it is percussed. But consolidation produces the same dullness or flatness as does percussion of the thigh.
2. Interposing fluid or pleural thickening between the stethoscope and the lung causes dullness to percussion.

The Two Principles of Chest Auscultation

1. If you plug up the loudspeaker or wear earmuffs, you will not hear the radio across the room. (Bronchial obstruction is like the first and pleural disease like the second.)
2. A compressed lung cries like a goat. (A compressed or consolidated lung produces egophony.)

A Caveat: Observer Variation

In this chapter, the pioneering studies of observer variability done in Great Britain are cited. More recently, similar findings have been reviewed from this side of the Atlantic (Koran, 1975).

One's individual physical findings must be correct because they are the bricks that comprise the wall of diagnosis. However, physical diagnosis can only be learned with experience. Accordingly, for the first few years, the student should use only those findings of which he is highly certain, remembering that the subjects in the papers on observer variability were all more experienced than he.

Self-study

At this point, construct a 5 × 7 contingency table for the following five diagnoses and seven techniques:

Diagnoses

1. Consolidation with the bronchus open
2. Consolidation with the bronchus closed
3. Pleural fluid
4. Pleural thickening
5. Pneumothorax

Techniques

1. Inspection of the tracheal position
2. Inspection of thoracic expansion
3. Palpation for fremitus
4. Percussion note
5. Auscultation of breath sounds
6. Auscultation for egophony or its equivalent (such as whispered pectoriloquy)
7. Other maneuvers

Of course, you may wish to try this exercise for other diagnoses and other diagnostic maneuvers.

See how much of the table you can fill in without turning to the answers (Table 16.5). It is all right to struggle a bit. Ask yourself questions such as these: In which of these diseases would the trachea be pulled toward the side of the lesions, in which would it be pushed away, and in which would there be no change? If you get stuck, reread the pertinent parts of the text.

If you did not reason out perfectly the findings for each of the chest syndromes, review the text and try again. You will probably get it nearly perfect the second time, and then you will never forget it. And you will have learned how to determine what you know and what you do not know.

A Pedagogic Note

There are many different styles of learning. Some persons learn best by reading textual material, understanding individual points, and then building to higher levels of complexity. For such learners, there is expository material throughout the early portions of this chapter.

Other students learn best by learning principles or by looking at tables. The preceding sections are for them. Still others learn by problem solving when presented with a visual puzzle. For them, the illustrative diagrams that follow can be used as the entry point for understanding the physical examination of the chest. However, regardless of your preferred style, at some point you should return to the beginning of the chapter and attempt to extend your understanding through the use of the other formats as well. In addition, you should be aware that not everyone will understand everything in this chapter on the first reading but will understand it later, especially when the work is used in consultation while actually examining patients' chests in the third and fourth years of medical school.

TABLE **16.5** *Textbook findings in unilateral chest syndromes*[a]

Finding	Consolidation with open bronchus	Consolidation (with atelectasis) with closed bronchus	Pleural effusion	Pleural thickening	Pneumothorax
Trachea shifted	—	Ipsilateral	Contralateral	Ipsilateral	Contralateral
Thoracic expansion	↓ Ipsilateral	↓ Ipsilateral	↓ Ipsilateral	↓ Ipsilateral	Not helpful[b]
Fremitus	↓ Ipsilateral	↓ Ipsilateral	↓ Ipsilateral[c]	↓ Ipsilateral	↓ Ipsilateral
Percussion resonance	↓ Ipsilateral	↓ Ipsilateral	↓ Ipsilateral	↓ Ipsilateral	↓ Ipsilateral
Breath sounds	T Ipsilateral	↓ Ipsilateral	T or ↓ Ipsilateral	↓ Ipsilateral	↓ Ipsilateral
Egophony	+ Ipsilateral	– Ipsilateral	±	—	—
Other maneuvers	+ Whispered pectoriloquy	—	—	—	+ Coin test

[a]Note that small lesions may not cause any of these findings.
[b]A pneumothorax, if small, might produce no change in chest expansion at a time when all other signs are present. Or, the diaphragm on that side might be paralyzed (depending on the cause of the pneumothorax) so that the costal margins would flare out more, making the expansion appear greater. On the other hand, with enough damage to the intercostal muscles, as in traumatic pneumothorax, there might be less expansion on the affected side.
[c]Tactile fremitus may be locally increased *above* an effusion.
+, present; –, absent or deceptive; ↓, decreased; ↑, increased; T, tubular.

A Self-test

As a further test of your understanding, look at the chest diagrams in Figs. 16-17–16-22. How many of these conditions can you diagnose correctly? Write all your answers down before looking at the answers in Appendix 16.3.

In each diagram, the arrows external to the outline of the chest indicate the degree of expansion with inspiration. An "E" indicates the presence of egophony or an equivalent such as whispered pectoriloquy. A "T" stands for tubular breathing. Other findings are as indicated in the individual legends.

Obviously, the lesions pictured are large. In reality, small lesions might have missing data, perhaps only tubular breath sounds or only egophony or its equivalents. There might be only a spot that has rales.

Diagnosis Based on the Location of Findings

Consolidation

It is possible to make an educated guess about the etiology of various localized consolidations on the basis of the segment of the lung in which they occur (Johnson and Bauer, 1961):

1. Upper lobes
   a. Apical segment: Pancoast syndrome or tuberculosis
   b. Anterior segment: carcinoma or pneumonia, especially that caused by aspiration
   c. Posterior segment: pneumonia, especially aspiration, or tuberculosis
2. Middle lobe and lingula: individually (unilaterally) pneumonia, carcinoma; bilaterally, bacterial pneumonia or disease involving the lymph nodes (especially tuberculosis)
3. Lower lobes
   a. Superior segment: anything
   b. Basilar segments: pneumonia or infarcts

A Caveat. True consolidated lobar pneumonia is rarely encountered today, with modern therapeutics having made the lobar heparization[9] state of pneumococcal pneumonia a rarity. The major cause of lung consolidation at present seems to be malignancy, either primary or metastatic to the lung.

For the Attending. The assistant professor's snare is the right interscapular area, a rich source of false-positive findings. The runner-up is the area overlying either scapula. Be very careful to compare both sides before diagnosing a unilateral lesion under the scapula.

Pleural Effusion

For pleural effusions, laterality can be a clue. In congestive heart failure, it has been taught that effusions are usually bilateral or right sided, and in purely left-sided effusions, concurrent pulmonary infarct, pneumonitis, malignancy, pericarditis, pancreatitis, or the "sympathetic effusion" of ascites should be considered (Weiss and Spodick, 1984; Wood and Wolferth, 1937), even if heart failure is also present. A 2009 review states that if there is asymmetry in pleural effusions associated with congestive heart failure, the right side predominates in 47%, and the left side in 19%. Explanations for the asymmetry include the greater extent of lung and pleural surfaces on the right side, and the greater frequency of right-sided versus left-sided decubitus positioning in patients with congestive heart failure (Wong et al., 2009).

The sensitivity and specificity of physical signs of pleural effusion may be comparable to those of conventional chest radiography

[9] Heparization, from the Latin *hepar* (liver), refers to the alveolar influx of red cells so massive that the lung at the autopsy table looks very much like a beefy red liver. This is to be distinguished from the therapeutic maneuver of heparinization, which uses a drug first derived from dog liver.

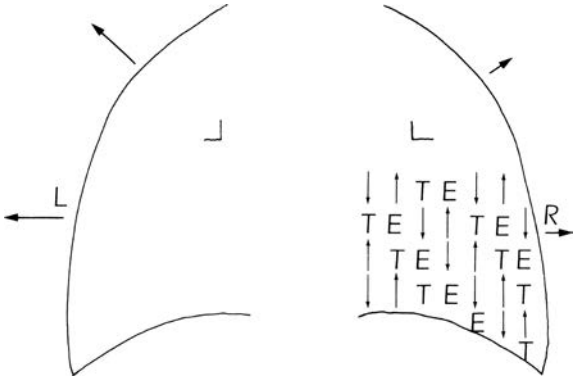

Figure 16-17 Posterior view. The patient obviously has restriction on the right side, which is presumed to be the abnormal one. The *upward arrows* indicate that tactile fremitus is increased (one might just as well say that tactile fremitus was decreased in all other fields; however, it is preferable to put all the findings in one area, and it would be unlikely for the right lower lobe to be the only normal portion of the lungs). The *downward arrows* denote a flat percussion note. T stands for tubular breathing and E stands for egophony. Rales, in this condition, might not be found or they might be found anywhere in the marked area.

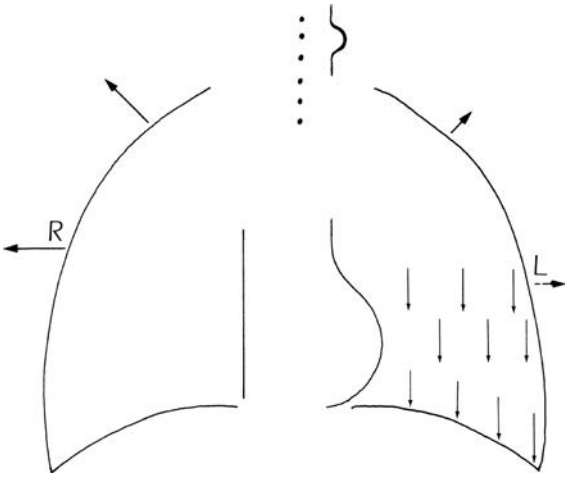

Figure 16-18 Anterior view, to show the tracheal deviation. The *downward arrows* mark an area in which the tactile fremitus is decreased, the percussion note is flat, and the breath sounds are decreased or missing.

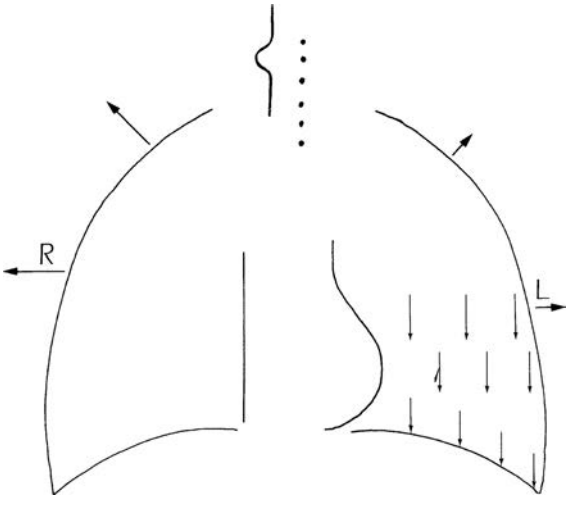

Figure 16-19 Anterior view. The findings shown by the *downward arrows* are as in Fig. 16-18. Egophony might also be found in the affected zone or in a thin band across its top.

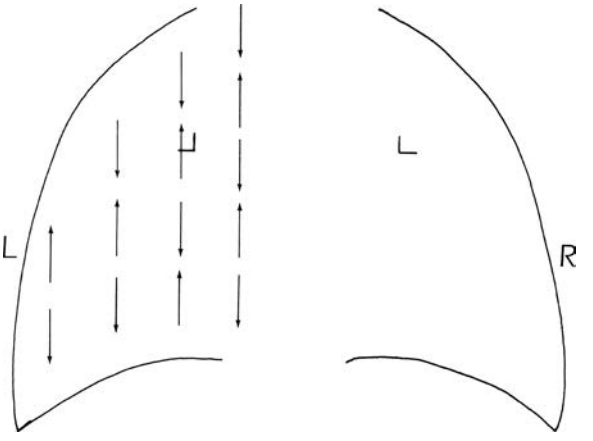

Figure 16-20 Posterior view. The *downward arrows* indicate an area of decreased tactile fremitus and decreased breath sounds. The *upward arrows* show a zone of a more resonant percussion note.

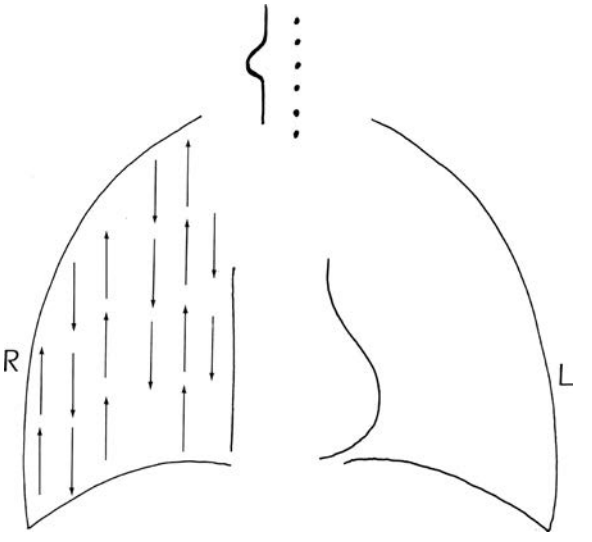

Figure 16-21 Anterior view. The *upward arrows* denote increased intensity of tactile fremitus and breath sounds; *the downward arrows* denote a dull percussion note. There are no rales, egophony, or whispered pectoriloquy.

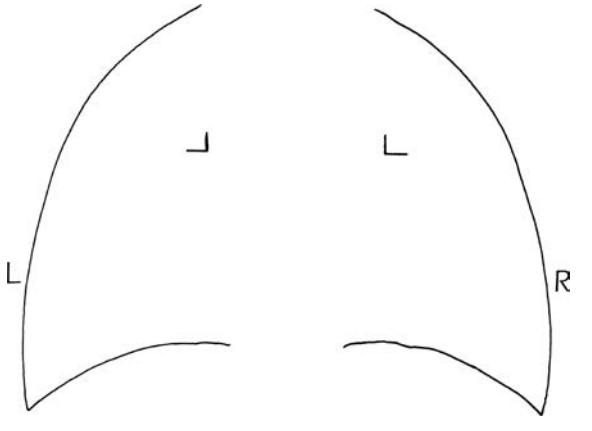

Figure 16-22 Posterior view. Hydropneumothorax (pick the side). Pencil in your own illustration. Check your entries with the text.

TABLE **16.6** *Accuracy of physical maneuvers in diagnosing pleural effusion*

Finding	Positive LR (95% CI)	Negative LR (95% CI)
Asymmetric chest expansion	8.1 (5.2–12.7)	0.29 (0.19–0.45)
Auscultatory percussion	7.7 (2.4–25.1)	0.27 (0.07–1.0)
Crackles	1.5 (1.1–2.0)	0.71 (0.52–0.97)
Diminished breath sounds	5.2 (3.8–7.1)	0.15 (0.07–0.30)
Dullness, conventional percussion	8.7 (2.2–33.8)	0.31 (0.03–3.3)
Pleural friction rub	3.9 (0.80–18.7)	0.96 (0.90–1.0)
Reduced tactile vocal fremitus	5.7 (4.7–8.0)	0.21 (0.12–0.37)
Reduced vocal resonance	6.5 (4.4–9.6)	0.27 (0.17–0.43)

Modified from Wong CL, Holroyd-Leduc J, Straus SE. Does this patient have a pleural effusion? *JAMA*. 2009;301:309–317.

(Rolston et al., 2008). A review of studies of the accuracy of various findings in pleural effusion (Wong et al., 2009) is summarized in Table 16.6.

Diffuse Lung Diseases

In previous sections, the value of the contralateral side (nature's own control) in the diagnosis of unilateral lesions is emphasized. However, physical examination can also be useful in the diagnosis of diffuse pulmonary abnormalities, such as chronic obstructive lung disease.

Physical Findings in Emphysema

Emphysema is abnormal permanent enlargement of air spaces distal to the terminal bronchiole.

In his classic study of patients with the "pink puffer" form of chronic obstructive lung disease, Fletcher noted: "Presumably so little attention has been given by clinicians to the problem of error in assessing physical signs because they seldom hunt in couples of equal seniority" (Fletcher, 1952). Fletcher had eight observers examine the same patients, and so he was able to calculate the percentage disagreement for a number of the classic signs of emphysema.

Inspection

The signs were impaired expansion (19% disagreement); movement *en bloc* (23%); kyphosis (27%); barrel chest (29%); wide subcostal angle (31%); and my own favorite, use of accessory muscles (41% each). Please note that no criteria were defined for use by the examiners in this study.

Palpation

The only palpatory sign of emphysema given by Fletcher was absent apical impulse (see Chapter 17). In patients with emphysema who do not have an apical impulse in the expected place (i.e., an "absent" apical impulse), it can sometimes be found in the subxiphoid region. I cannot explain Fletcher's 26% disagreement rate, but others have also found only "fair" agreement ($\kappa = 0.30$) on location of the apical impulse. On the basis of a study in which only a small number of patients (6) had a subxiphoid apical impulse, the sign was found to have a 27% sensitivity but a 98% specificity for moderate COPD (Badgett et al., 1993).

Percussion

The percussive signs studied by Fletcher were impaired cardiac dullness (29% disagreement), impaired liver dullness (32% disagreement), and generalized hyperresonance (33% disagreement). In another study, impaired cardiac dullness (at the left sternal border, fourth intercostal space, compared with the left upper chest) had "moderate" interobserver agreement ($\kappa = 0.49$). The sensitivity was only 0.16, but the specificity for moderate COPD was 0.99.

Auscultation

The auscultatory sign was impaired breath sounds, for which there was a surprising 29% disagreement.

Others have found that with trained examiners, there is a strong correlation between the perceived BSI and the percent-predicted FEV_1. Although BSI was insensitive to mild degrees of ventilatory impairment in one study, definitely reduced intensity was a strong indicator of obstructive pulmonary disease, and normal breath sounds virtually excluded the possibility of a severe reduction in FEV_1 (Pasterkamp et al., 1997a). In a study that used a multivariate analysis, diminished breath sounds were the best predictor of moderate COPD (FEV_1, <60% predicted) despite only "moderate" interobserver agreement ($\kappa = 0.47$). Sensitivity was 65% and specificity was 96% (Badgett et al., 1993). In the Badgett study, 92 patients with self-reported COPD or cigarette smoking were examined; only 15 of them had "moderate" COPD, with the gold standard being measurement of the FEV_1.

Self-test. If the prevalence of moderate COPD is 16%, what is the positive predictive value of diminished breath sounds? The negative predictive value? (Answer is in Appendix 16.4.)

Summary

Given the above, it is not surprising that there was a 29% disagreement rate for the global evaluation of "emphysema" (Fletcher, 1952). Because of the large interobserver disagreement about the physical signs and because chest radiographs have poor sensitivity for detecting the disease, spirometry is considered to provide the definitive diagnosis. It is also useful for staging and monitoring disease progression (Mannino et al., 2000).

The signs studied by Fletcher are not the only ones that are useful in diagnosing emphysema. On inspection, one will notice intercostal retraction and several Hoover diaphragmatic signs (discussed earlier in this chapter). Tactile fremitus seems to be decreased, but because this is a generalized phenomenon, it is difficult to quantitate. On percussion, the heart is vertical. This finding is sometimes referred to as a "drop heart" (shaped like a teardrop) or as "microcardia"

because of its resemblance to the small heart of adrenocortical insufficiency. On auscultation, one also notes distant heart sounds and a prolonged expiratory phase of the breath sounds, which correlates with a prolonged clinical forced expiratory time.

A special maneuver that is rediscovered about every 10 years is the match test, sometimes called the *Snider test*. The patient is asked to huff (not puff) a match out. Huffing is performed with the mouth and lips open as wide as possible to prevent the direction of a jet of air. The normal individual can huff a match out at 6 to 8 in. on the first try. Patients with sufficient obstructive (or restrictive) disease have great difficulty with this test. Some require multiple trials to huff out the match at 6 in., and some with severe disease are simply unable to accomplish this feat at all. For purposes of standardization, the match should be lit and allowed to burn down for a few seconds, and then be held still, directly in front of the mouth. Surprisingly, even this seemingly objective measure had only "fair" interobserver agreement in one study ($\kappa = 0.39$). With a cutoff of 10 cm (about 4 in.), the sensitivity for moderate COPD was 0.53 and the specificity was 0.88 (Badgett et al., 1993).

For the Attending. One can become very proficient at predicting the spirometric values from the results of the clinical examination; however, frequent practice is required to maintain this skill. More important than a display of roundsmanship is to convince young physicians that it can be done. An insistence on precision is heuristically and clinically useful because it leads to the ability to classify the majority of patients as obviously normal or obviously impaired.

Unilateral Hyperlucent Lung Syndrome: Very Advanced

There is only one type of emphysema in which one can use the contralateral side as a control for unilateral disease. This is the unilateral hyperlucent lung syndrome or Swyer–James syndrome of unilateral emphysema.

One such patient had, on inspection, a restrictive pattern of breathing on the affected side. Palpation and percussion were unremarkable. The breath sounds were decreased on the affected side.

One could conclude from this that the shibboleth of "increased" or hyperresonant percussion note in emphysema is actually a reflection of the thin chest wall in these patients and, like the famous "increased AP diameter," is an artifact of weight loss and not a reflection of lung pathology.

Unfortunately for this hypothesis, some other patients with this syndrome are stated to have decreased tactile fremitus and an increased (hyperresonant) percussion note only on the affected side (Figueroa-Cases and Jenkins, 1968; Swyer and James, 1953).

Were my hypothesis correct about the increased percussion note coming from the thin chest wall, then there would not be unilateral increase in Swyer–James syndrome. But in a second personal patient, the percussion note was also not changed on the affected side. Could others have described what they thought they should hear, after they saw the chest film?

A Statistical Interlude: The "Two Types" of Chronic Obstructive Lung Disease

Two forms of chronic obstructive lung disease, each supposedly antipodal to the other, have been popularized. Ectomorphs with emphysema were called "pink puffers" because they were able to maintain oxygenation, and they also puffed against pursed lips to keep their intrabronchial expiratory airway pressure high. The group with chronic bronchitis was often cyanotic and tended to be mesomorphic or endomorphic and edematous, hence the term "blue bloaters." While the pink puffers had small hearts, the blue bloaters were often suffering from right-sided heart failure.

Although these two names call to mind the characteristic clinical appearance, emphysema is now a pathologic diagnosis and chronic bronchitis a historic one, based on the production of at least two teaspoons of sputum every morning for at least 3 months out of at least 2 consecutive years.

Both types of chronic obstructive lung disease may be associated with the downward tracheal tug of inspiration described earlier in this chapter. This suggests to me that both involve some degree of pulmonary fibrosis. When one actually tries to categorize each patient into one or the other of these two stereotypes, it is discovered that the largest single group is a third consisting of patients who do not clearly fit into either category.

Why then has the effort at dichotomization persisted?

Figure 16-23 shows two camels or at least the part we are interested in, the humps. The one-humped camel is a dromedary, which inhabits North Africa and Western Asia. This Arabian camel is known to scientists as *Camelus dromedarius* (var. *gaussianus?*). The two-humped camel is an Indian or Bactrian camel, known to scientists as *Camelus bactrianus* (var. *bimodalus?*). This two-humped camel has been hiding within the pages of all works concerned with the concept of disease.

To think of disease as a qualitative (therefore also quantitative) difference from something called "health" or "normality," we act as though we believe that persons can be assigned to one or the other hump of the bimodal camel. One hump is "healthy" and the other hump is the disease we are studying. Just as Aristotle could not tolerate an undistributed middle (an act is either good or evil but not both), the bimodal way of medical thought cannot easily tolerate an undistributed middle. The patient must either have the disease or not have it. There are two humps and nothing in between but the camel's spine.

For example, a patient either has the malaria parasite in his body and has malaria, or he does not have the parasite and does not have malaria. There are no borderline, near-normal, or high-normal amounts of the parasite. The situation is dichotomous or bimodal, black and white. Unfortunately, the bimodal camel is not as common as we might like. Obesity is clearly a disease when the subject is 100% overweight. But what about the subject who is 1% or 10% or 20.01% overweight? The frequency distribution of body weight is Gaussian not bimodal. Similarly, blood pressures have a

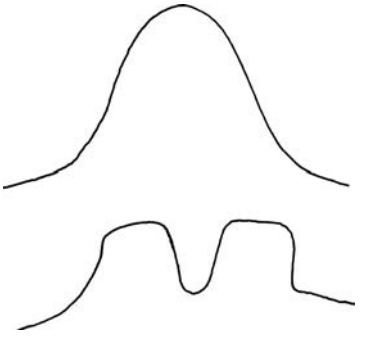

Figure 16-23 The one- and two-humped camels.

unimodal distribution, and the definition of high blood pressure must be arbitrary. (In 1988, the demarcation seemed to be a diastolic varying, with author, between 90 and 100 mm Hg. At present, the acceptable systolic pressure counts too—see Chapter 6.) With a laboratory test, one might wish to use a standard probability parameter for defining the line of demarcation, such as the mean plus or minus so many standard deviations. (Such statements are often called "probabilistic statements.") But with a disease, we are forced to make a judgment about whether a disease is or is not present. For the individual patient, a probabilistic statement of affliction is not helpful.

Thus, the effort to dichotomize patients persists. Unimodal distributions with probabilistic cutoffs are intellectually unsatisfying. The bimodal camel is much more appealing. Once there is a variable that can be measured, one can obtain the correct answer and is left only with the problem of effective therapy. Dichotomies, even when incorrect, "feel better" to the doctor.

For the Attending. One might be inclined to conceive of chronic obstructive lung diseases in the elderly as a spectrum with pink puffers at one hump and blue bloaters at the other. (Of course, in this situation, we are speaking of two disease states, not a healthy and an unhealthy state.) Also, the situation is more complicated because there is more than one variable involved in the definitions (lung tissue destruction, sputum production, oxygen saturation, etc.).

It is important to recognize the problem of bimodal thinking because it may inhibit the recognition of new clinical entities. For example, in Conn syndrome the bimodal concept holds that either a patient has an adrenal tumor, which secretes clearly abnormal amounts of aldosterone and which cannot be suppressed by certain standardized physiologic maneuvers, or he does not have the tumor. In the latter case, he does not have elevated levels of aldosterone, and the normal levels present can be clearly suppressed by the standard maneuvers. In this scheme, there is no middle ground. This may be one reason why it took so long to appreciate the relative frequency of hyperaldosteronism due to bilateral adrenal cortical hyperplasia (as opposed to an adenoma).

Clinical Examination in Perspective

Pulmonary Embolism with or without Infarction: The Limitations of Clinical Examination

The clinical presentation of pulmonary embolism is variable and nonspecific, making accurate diagnosis difficult. Symptoms may be absent even with severe pulmonary embolism. Maintenance of a high index of suspicion is critical (Stein et al., 2007). Pulmonary embolism clearly reveals the limitations of the history and physical examination as a test of hypotheses, as contrasted with their usefulness as generators of hypotheses. That is, the history and physical are quite helpful in suggesting the diagnosis of pulmonary embolism, but not very precise in confirming or excluding that diagnosis.

There are 12 signs that may occur when the pulmonary embolus is massive (Gorham, 1961):

1. Pulsation in the second or third left interspace at the sternal margin
2. P2 greater than A2 (see Chapter 17 for this and other cardiac findings)
3. A pleural (or pleuropericardial?) rub near the pulmonic area
4. A systolic murmur at the pulmonic area (first described by Dr Litten, frequently mentioned in these pages)
5. A diastolic murmur in the same place
6. An interscapular bruit
7. Unilateral decreased inspiratory expansion
8. Increased dullness to the right on percussion of the cardiac silhouette
9. Distended neck veins (with the patient sitting)
10. A gallop
11. Hepatomegaly
12. Die rote Blutwelle (the red blood wave—a red arterial wave that passes over the cyanotic face whenever a piece of the obstructing embolus becomes dislodged, permitting some additional oxygenated blood to pass into the systemic circulation)

These signs were collected by a pathologist, all of whose cases had autopsies performed. Thus, they are signs of a massive pulmonary embolism, severe enough to kill the patient. Even in such a severe case, the signs (especially 8 through 11) are not pathognomonic, and sign 12 has only been reported once (and seen in one other case of which I am aware). The absence of all of these signs does not ensure the absence of a pulmonary embolus.

Pulmonary embolism is among the most treacherous of all conditions confronting the physician because of the high mortality rate (30% if untreated) and the difficulty in diagnosis. The estimated annual incidence in the US is 650,000 cases, and the diagnosis is missed more than 400,000 times each year. Eventual mortality is five times higher if the diagnosis is missed on the patient's initial presentation (Miller and Feied, 1995).

According to autopsy studies, diagnostic accuracy did not change much between 1934 and 1977. In the earliest series (1934–1939), the sensitivity of the clinical diagnosis was 41% and the specificity 99%. In the latest series (1975–1977), the sensitivity of clinical diagnosis was 44% and specificity was 97% (Anderson et al., 1989). In 300 autopsies performed in 1960, 1970, and 1980, pulmonary embolism was the most commonly missed major diagnosis; 63% had been missed clinically, and performance did not improve significantly over time (Goldman et al., 1983). It is possible that the ready availability of ventilation/perfusion scans, improvements in spiral CT scans, and more frequent monitoring of oxygen saturation will improve these figures—if the physician thinks to order them. The frequency of various clinical findings is given in Table 16.7. Submassive embolism often resembles congestive heart failure, asthma, or primary hyperventilation (Miller and Feied, 1995).

Physical Examination and Role of Chest Radiograph

Historic Perspective

In the days of liberal third-party payments for in-hospital tests, it became customary to obtain an admission chest film on all patients to "rule out pathology," even in the absence of clinical findings. The yield of this screening test was low.

Recently, Blue Cross–Blue Shield commissioned a study of the utility of routine chest radiographs, which concluded that the routine admission and preoperative chest film should be abandoned because patients in whom chest films are likely to improve outcome are best identified by a careful history and physical examination (Tape and Mushlin, 1986).

TABLE **16.7** *Frequency of various symptoms and signs in patients with pulmonary embolism: hospitalized patients with angiographically proven diagnosis (first figure) and patients from a national collaborative study that included a broad spectrum of severity (second figure)*

Symptoms	Frequency (%)
Dyspnea	84; 79
Pleuritic chest pain	74; 47
Apprehension	59
Cough	53; 43
Hemoptysis	30; 6
Sweating	27
Nonpleuritic chest pain	14
Syncope	13
Signs	
Tachypnea (16/min; > 20/min)	92; 57
Fever (37.8°C, 100°F; >38.5°C)	58; 2
Diaphoresis	53
S3 or S4 gallop	44
Thrombophlebitis	43; 47
Lower extremity edema	36; 47
Cardiac murmur	34
Cyanosis	19

From Miller GH, Feied CF. Suspected pulmonary embolism: The difficulties of diagnostic evaluation. *Postgrad Med.* 1995;97:51–58, with permission. Second figure, when available, from Stein PD, Beemath A, Matta F, et al. Clinical characteristics of patients with acute pulmonary embolism: Data from PIOPED II. *Am J Med.* 2007;120:871–879, with permission.

Another study found that the absence of some pulmonary auscultatory findings (wheezes, rhonchi, rales, diminished breath sounds, etc.) excluded pneumonia on a chest film with a greater than 95% certainty (Heckerling, 1986). Of course, one would prefer 100% certainty in a screening test, which should be highly sensitive. But inspection, palpation, percussion, and special vocal maneuvers were not even performed! Another recent study revealed that only 3% of the radiographs taken in 75 febrile neutropenic patients with no signs or symptoms of pneumonia showed what might have been a pneumonic infiltrate (Jochelson et al., 1986).

Clearly, these studies, although they provide some estimate of the sensitivity of the clinical examination, were not designed to obtain maximum diagnostic information from the physical examination but to exclude some statistical portion of the population from having a chest radiograph. However, the purpose of a physician is not the same as the purpose of an insurance company. The physician performs a physical examination in order to generate hypotheses about what is wrong with the patient, not to spare the cathode-ray tube.

Circumstances in Which Physical Examination Is Superior to Radiography

Although clinical examination is often used simply to infer findings that the chest radiograph can demonstrate in replicable form, the clinical examination is actually superior to the chest radiograph in certain circumstances—above and beyond the fact that clinical examination can be repeated frequently without the need to transport patients or heavy equipment. For one thing, certain findings are accessible to the stethoscope or to the observer's sight and touch, which are hidden from the X-ray beam. As Dr Gerry Rodnan of the University of Pittsburgh used to say, "You can't hear rales on a chest X-ray." For example, there is a roentgenologically silent portion of the chest behind the heart silhouette. To explore this area, one must order a lateral chest film. Unfortunately, it is almost impossible to get a lateral film on a bed-bound patient. However, you can always go over the patient with your stethoscope.

Another example is the circumstance of widespread pleural scarring (white-out), which leaves the chest roentgenographically silent but not necessarily acoustically so. Sometimes the stethoscope can detect changes occurring in the residual lung when the radiograph cannot.

The clinical examination can also point to the correct diagnosis of findings that have been erroneously attributed to pleural effusion on the basis of the radiograph—for example, pleural thickening. In addition, physical examination has the advantage that it is dynamic rather than static. In some patients, inspection of the subcostal angle movement can show that the correct diagnosis is an elevated diaphragm (discussed earlier in this chapter).

Elevation of the diaphragm because of paralysis can be detected (e.g., during inspection or percussion for diaphragmatic movement). If the diaphragm is elevated because of previous pneumonectomy (whose scar appears on physical examination but not on the radiograph), the absence of egophony can be the important clue. Alas, nothing is perfect. If the elevated diaphragm is caused by atelectasis, the latter may itself produce egophony, thus suggesting the wrong diagnosis of pleural effusion. But in that case, inspection for tracheal deviation may make the distinction.

The distinction between a fat person with a high hemidiaphragm and a person with a lower-lobe infiltrate is one of the most difficult in all of physical diagnosis. This is also a situation in which the chest film may not be as helpful as one might wish. Inspection, palpation, and percussion may all be equivocal. On auscultation, breath sounds are diminished over the dull area in both situations. However, the presence of tubular breathing, egophony, bronchophony, or whispered pectoriloquy, individually or combined, shows that one is dealing with a pathologic condition within the lung and not just a high hemidiaphragm (without underlying atelectasis), although the latter might be detected by the Hoover sign.

In recent decades, one has heard erudite discussions on chest films revolving around the controversy as to whether a finding represented a right middle-lobe silhouette sign or a right lower-lobe lesion or both. This could have been easily resolved by physical examination, had the examiner remembered to include the anterior lung fields in his percussion and auscultation.

Limitations of Portable Chest Films

Probably the best-known problem with the portable chest film is that most of the basal lung fields are not well visualized. Thus, a false sense of security can be generated by "normal portable AP." In fact, portable films are technically compromised in 6% to 37% of cases (Sherrier and McAdams, 1986). In one study using CT scans as the "gold standard," 17% of cases had an empyema that was missed by the portable film, 13% had large pleural effusions that were missed by the portable film, and 15% had malpositioned thoracostomy tubes

that were not picked up on a portable film (Mirvis et al., 1987). In all, 70% of the CT scans added useful information not available from the portable film. Of course, things are probably worse than the above figures show because CT itself had an overall diagnostic accuracy of only 72% for empyema and 95% for lung abscess in another study from the same institution (Mirvis et al., 1985).

Additionally, the heart size is magnified in a portable film. It is so difficult to evaluate cardiac status on an AP film that it is well worth the effort to obtain a PA film. Even a patient who is not able to travel to the radiology department may be able to sit for a few minutes with his back to the X-ray beam, hugging the cassette to his chest (T. Dorman, *personal communication*, 1998). You may help support the patient, preferably wearing a lead apron to keep the technician happy; a few extra X-ray exposures in the course of your career will not harm you and could conceivably be slightly beneficial if radiation hormesis (Luckey, 1991) turns out to be a real effect.

Because radiographs too are limited, even if a high-quality film can be obtained, it is fortunate that the physician with clinical examination skills is not totally dependent upon a picture of a shadow—a chest radiograph—for his total understanding of the patient's chest or of the patient.

Furthermore, the sophomore should appreciate that there is a lot more diagnostic inaccuracy in the reading of the chest film than has previously been published (Kuritzky et al., 1987). Considering the relative emphasis in contemporary medical education given to the reading of the portable chest film versus the performance of an accurate physical examination, it might even be that the physical is inherently more accurate—if only it were taught as vigorously! (For more in this line, see Chapter 17).

Conclusions

In summary, the chest roentgenogram is often useful as an independent covariable in physically assessing the patient's chest. However, it is not a perfect covariable and can therefore never substitute completely for the examination of the patient's chest by a thoughtful and skilled physician. Conversely, while there is enough overlap between the physical examination and the chest film to provide a good game of "predict the chest film," there are certain findings on the chest film that, by their nature, will always come as a surprise.

The chest film has also had an important impact of an epistemologic nature. In the 19th century, physical diagnosticians correlated their findings with autopsy. Thus, the findings defined diseases of such magnitude as to be usually fatal. With the chest film, the concept of a disease such as pneumococcal pneumonia could be extended to small nonlobar lesions, insufficient to kill but sufficient to make a roentgen shadow. In many of these latter cases, physical findings are subtle or absent.

Appendix 16.1

Auscultatory Percussion for the Detection of Pleural Effusion

For the Resident. The text of Webb's 1927 article (Webb, 1927) follows:

> Refinements in diagnosis are useful, and in the recognition of pleurisy with effusion, roentgen-ray facilities are not always at hand. For several years. I have found a method of auscultation with percussion of great service in detecting effusion.
>
> The bell of the stethoscope is placed in the lower axilla, when the patient is seated, and the spinous process of the vertebrae tapped gently from above downward with the percussion finger. If an effusion is present, a change to a note of higher and shorter pitch is detected at a spinous process which, in the case of the affected side, is above that of the normal side. In many instances, this change of tone accords with the apex of the Grocco triangle, and it does not in general coincide with the upper edge of the fluid content. The method should be practiced on normal persons, with the eyes closed, and it will be determined that the change of note is at the same spinous process on each side, about at the twelfth dorsal.
>
> With thickened pleura, and with advanced tuberculous processes in the base of one lung, the tone related to this side may be changed throughout the range of percussion as compared with that of the opposite side, but there is no sudden change of note as there is in the presence of fluid. Should the effusion completely fill one pleura, no sudden change of note will be observed, but in such a case palpation of the trachea yields an important clue, as indeed it does in all cases of pleural effusion. The same procedure may be followed with the patient leaning a little forward, and gentle percussion made downward over the sternum. With a bed patient who is unable to sit up, the stethoscopic bell can be applied in the median axilla and gentle percussion made from the sternum toward the stethoscope: a distinct change of note will be observed before the bell is reached on the side containing the effusion, whereas on the normal side no such change will be observed.
>
> This method of auscultatory percussion has been carried out in a large number of patients with and without pleuritic effusion, and the results have been carefully checked with aspiration and roentgen-ray examination.

Personal Experience. This technique seems to work best with massive pleural effusion. Smaller effusions that produce only blunting of the costophrenic angle on the PA chest film do not have this sign in my experience although they are sufficiently large to be detected by other techniques of physical examination.

Appendix 16.2

Answer to the Self-test on the Specificity of Auscultatory Percussion, Page 304

The specificity of auscultatory percussion cannot be determined from Guarino's study, which included no patients without intrathoracic pathology. Thus, both true negatives and false positives in the study are 0 and 0/0 or the specificity is indeterminate.

Appendix 16.3

Answers to Self-test on Diagnostic Findings, Figs. 16-17–16-22

Figure	Diagnosis
16-17	Right lower-lobe consolidation without bronchial obstruction
16-18	Left lower-lobe consolidation with a closed bronchus (or left lower lobe with severe pleural thickening, scarring, and retraction)
16-19	Left pleural effusion
16-20	Left pneumothorax

16-21 The front view of Fig. 16-20.[10] The trick, as in real life, is not to be fooled by the side that seems to be abnormal. Here, this is actually the normal side. The clue to solving the puzzle comes from tracheal inspection. If the trachea is shifted to the right, one sees from Table 16.5 that there are only three possibilities: left pneumothorax, left pleural effusion or thickening, and right consolidation with a closed bronchus. The second possibility is excluded by the relatively hyperresonant percussion note on the left, and the third is excluded by the relative increase in tactile fremitus and BSI on the right.

16-22 On the bottom are the physical signs of pleural effusion and on the top are those of a pneumothorax. In addition, there should be a succussion splash.

Appendix 16.4

Predictive Value of Diminished Breath Sounds for the Detection of Moderate COPD

In a population of 1,000 persons, TP = 104, FN = 56, FP = 33.6, and TN = 806.4. Thus, the predictive value of a positive test is 76%, and the predictive value of a negative test is 94%.

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[10] This frustrating piece of trickery was inserted to emphasize two points: (a) One can still reason out the diagnosis and the location in the absence of any focal finding (such as egophony, whispered pectoriloquy, decreased excursion, etc.) and in the absence of information about a diagnostic sign (here, the coin test) and (b) Tracheal position, which I have noticed to be the first chest physical sign to be jettisoned by the jejune, is actually one of the most valuable, when used in conjunction with the other findings.

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CHAPTER

17

The Heart

We insist on the same regimen plus the use of chicken soup.[1]
—Barron Larrey (Napoleon's surgeon),
Surgical Clinics from Military Camps and Hospitals Between 1792 and 1829, vol. 10. Chez Gabon, Paris, 1829

Points to Remember:

- Feel the precordium for impulses, which are likely to signify a malfunctioning heart.
- When listening to the heart, first identify systole, which begins with the first heart sound.
- Listen to one time at a time; remember that there are two diastoles: early (just after the second heart sound) and late (just before the first heart sound).
- For every murmur, one should attempt to describe the dimensions of timing, shape, location, radiation, pitch, timbre, intensity, and effects of special maneuvers.
- Some believe that all positive auscultatory findings must be confirmed with advanced technology. This will not be possible for negative findings until all physicians have a color-Doppler-echocardiograph-cum-technician in their black bag.

Inspection

The point of maximum impulse (PMI) is usually the only pulsation that can be seen. Normally, it occurs during systole at the apex of the heart. Some normal persons do not have a visible PMI, especially if they have a thick body wall. Theoretically, if there is no visible systolic apical impulse, but there is a visible pulsation elsewhere (as rarely occurs), that pulsation would have to be considered the PMI. (If there is no visible pulsation, the PMI may still be found by palpation—see later in this chapter.)

A Method

Look for the PMI with the patient standing erect, recumbent, or sometimes simply sitting. Some also recommend examination in the 45-degree left-lateral decubitus position (Eilen et al., 1983). Not surprisingly, the PMI will be laterally displaced in this position. Illuminate the chest with a light shining at an oblique angle so that the shadows will accentuate any precordial pulsations. Perform inspection and palpation in the supine and left-lateral positions during normal respiration and also during suspended respiration after a forced full exhalation. The latter maneuver places the chest wall closer to the heart (Ewy, 1972).

There are four questions to be answered by inspection of the precordium, as outlined below.

1. Can You See a PMI?

Obviously, if you cannot see a PMI, you do not need to answer the other questions, but you can instead proceed to palpation. About 75% of patients seen for a routine checkup will not have a visible PMI. However, you should be aware that after you have palpated the precordium and found the palpable PMI, it is often possible to go back and find a visible PMI by specifically looking at the area of the palpable PMI.

2. Is the PMI Systolic?

Normally, the PMI is systolic. One reported sign of constrictive pericarditis is a diastolic PMI (Stapleton and Groves, 1971). However, in constrictive pericarditis, a systolic retraction of the PMI (the Broadbent sign) may occur, and this might look like a diastolic PMI in a patient with a fast heart rate (also see "Other Palpatory Findings," later in this chapter, for other causes of palpable systolic refraction). The Broadbent sign has also been reported in cases of right ventricular hypertrophy.

Perloff advises marking the skin with ink and illuminating obliquely with the beam of a pocket flashlight. Precordial retraction (not pulsation) is thus more readily seen than felt, especially when viewed across the chest or from the patient's feet.

3. Where Is the PMI Located?

Normally, a visible PMI is located at the apex. The apex is normally located in the fifth intercostal space at (or medial to) the midclavicular line. An old rule states that if the PMI is in the sixth intercostal space or below, or is lateral to the midclavicular line, it is abnormal, irrespective of the other features of the cardiac examination. Such displacement is usually from left ventricular enlargement (*vide infra*), but sometimes results from leftward mediastinal shift. (The distinction is based on the fact that only the latter will have a leftward tracheal shift.)

Why the Midclavicular Line?

A few precise physicians and at least one of the better physical diagnosis textbooks recommend describing the PMI in terms of its horizontal

[1] This quotation concerns the first removal of pericardial fluid from a patient with apparent tamponade. Pericardiocentesis was not technically performed, as the patient had a sword wound entering the pericardium, and a catheter was simply passed through the wound track. This is not the first reference to chicken soup as a medicine. Credit for that discovery goes to an informant of Pliny the Elder, in *Natural History Book* 29, 25:78: "Parthians prefer to put chicken brain on the wound. The soup made from the chicken is an excellent medicine for this and also miraculous in many other conditions."

distance from the midsternal line. However, the midclavicular line is preferred as a reference for the following reasons:

1. When reading the case record, it is impossible to know the meaning of a PMI located *x* cm from the midsternal line because we do not have a value for the "correcting" denominator (i.e., the transverse thoracic diameter at the same level).
2. There is no one normal value for the location of the PMI in terms of distance from the midsternal line. Whereas 6 cm from the midsternal line might represent PMI displacement in a neonate with congenital heart disease, it could be evidence of microcardia in a Sumo wrestler. The single "normal" value available to the literate proponents of the midsternal line ("<10 cm") is based on a total experience of 12 men and 6 women of unknown body size (Beilin and Mounsey, 1962).
3. The left midclavicular line is very convenient because displacement of the PMI lateral to this line is abnormal, whether resulting from a mediastinal shift or from an inherent cardiac disease.
4. The objection voiced against the midclavicular line, that it is "subjective," is silly, as shown by the following method.

A Method

1. Locate the medial head of the left clavicle (collar bone) where it articulates with the first rib and mark it at its most medial point.
2. Mark the clavicle at its lateral extreme, which is just above the acromion of the scapula, between the lateral edge of the trapezius (behind) and the superior deltoid muscle (in front).
3. Find the midpoint of the line connecting the above two points.
4. From Dorland's dictionary (1913), the midclavicular line is "a perpendicular line let fall from the center of the clavicle" (the midpoint you have just identified). DaCosta (1909) stated that "this line, although commonly termed 'mammillary,' rarely passes through the nipple" (Rytand, 1968). Determinations of the position of the midclavicular line by this method correlated well with radiographs, whereas persons who simply guess at its position miss it by up to 4 to 6.5 cm (lateral and medial misplacement, respectively) (Naylor et al., 1987).

When Does the PMI Originate from the Right Ventricle?

In patients with severe right ventricular hypertrophy and dilatation, the left ventricle will be displaced posteriorly. Careful palpation will show that the PMI is contiguous with the impulse along the left sternal border (*vide infra*), and thus originates from the right ventricle. A *point of medial retraction*—an area between the impulse and the sternum that is either motionless or retracts—identifies the left ventricle as the source of the apical impulse (Ewy, 1972).

Hypertrophy and Dilation

In left ventricular hypertrophy, the PMI and the apex might still be in the usual place if the patient has no accompanying left ventricular dilation (enlargement). If the patient does have chamber dilation, the apex may be displaced laterally. Note that hypertrophy refers to the wall thickness, as learned in pathology and measured by echocardiography. Dilation refers to the size of the cavity that the ventricle surrounds, manifested by the size of the silhouette as determined by percussion or radiography. ("Ventricle" comes from the Latin word for "sack." Sometimes we are talking about the thickness of the material walls of the sack ["hypertrophy"] and sometimes about the internal dimensions [the cavity proper] or the size of the total ["enlargement"].)

Other Abnormalities

In right ventricular hypertrophy, the PMI can be seen in the subxiphoid region of the epigastrium. In dextrocardia, the PMI will be on the right side of the chest.

Teaching Hint. You may wish to mark the patient's chest (with his permission) with a water-soluble marker after you have found the PMI. This will help you to learn percussion of the heart border without having to send the patient for a fluoroscopy (rarely available these days) or for a radiograph. The heart border should be located just outside the PMI.

A massive pericardial effusion is an exception to the last statement, although most of the time such patients will not have a visible PMI. Why not? (Write down your answer before looking at Appendix 17.1.)

4. Is the PMI a Single Impulse?

Sometimes the PMI has a double impulse (in time). (Usually, this is more easily felt than seen.) This can be a valuable sign of idiopathic hypertrophic subaortic stenosis (IHSS) or bundle branch block (BBB) with asynchronous contraction of the ventricles.

It has been pointed out (Basta and Bettinger, 1979) that double systolic apical impulses are encountered in other conditions, including fixed aortic stenosis, ischemic heart disease with anterior wall dyskinesia, and a variety of myocardial diseases.

A triple apical impulse was found in 17 of 24 patients with subaortic stenosis.

Teaching Trick. If the PMI is in an intercostal space, a tongue depressor held against the rib, with the end on the PMI, may be used as a lever to magnify the PMI for your scrutiny.

Palpation

A Method

Some persons palpate for wide-area, low-frequency events (such as right ventricular heaves) with the hypothenar surface. For restricted-area events such as the PMI, some palpate only with the fingertips, and some are best able to detect vibrations with the area of the palm at the base of the fingers (see Chapter 16).

As Dr Brendan Phibbs of Arizona advises, when you palpate the precordium, leave fingerprints. Apply gentle force to elicit motion and get the precise character of the motion. Dr Phibbs finds that the left ventricle is best appreciated with the fingers in the intercostal spaces left of the midclavicular line, whereas the right ventricle is best appreciated with the heel of the hand applied to the left parasternal area.

See what works best for you.

The PMI

As indicated above, palpation is a more sensitive technique for assessing the PMI than is inspection. If you cannot see the PMI but

you can feel it, then you will have to use palpation alone to answer questions 2 through 4 above. Even if you can inspect the PMI, you should always use palpation to check the answers. In addition, palpation can give some information that is very difficult or impossible to obtain from inspection.

Size

If the diameter of the PMI in its longest axis is larger than 2.3 cm (the diameter of a quarter), it is clearly abnormal. If it is 2.0 cm, the size of a nickel or larger, it is probably abnormal; however, many sophomores will think their own PMI is the size of a nickel, if they do not hold a nickel in their hand before palpation. With experience, you can appreciate more subtle distinctions. A PMI of 1.7 cm (the size of a penny) or smaller is normal.

One study (Eilen et al., 1983) showed no correlation between the left ventricular volume and the location of the PMI with the patient rolled into a 45-degree left-lateral decubitus position. However, in that position, an apical diameter greater than 3 cm (the diameter of most stethoscope bells) was an indicator of left ventricular enlargement. The sensitivity was 92% and the negative predictive value (PV) was 95%. Another study (Heckerling et al., 1993) showed that in cases in which the PMI was palpated (53% of patients), an apical impulse diameter greater than 3 cm in the 45-degree left-lateral decubitus position was 100% sensitive and 40% specific for increased left ventricular end-diastolic volume (LVEDV) and 100% sensitive and 30% specific for increased left ventricular mass (LVM).

Duration

For the Resident. The PMI normally occupies two thirds of systole or less. Accordingly, one can detect a prolonged duration by noting whether the PMI reaches or exceeds the second heart sound. In one study, such a prolonged PMI was found in 13 of 13 patients with left ventricular hypertrophy (as judged by electrocardiographic voltage criteria). This compares with only 8 of the 13 patients detected by an increased forcefulness (Beilin and Mounsey, 1962).

Location

As noted above, the PMI should not be lateral to the left midclavicular line nor below the fifth intercostal space. *Either* location is abnormal.

Displacement in the absence of mediastinal shift requires chamber enlargement, not just wall hypertrophy; only 8 of 13 patients with electrocardiographic evidence of left ventricular hypertrophy had a displaced PMI (Beilin and Mounsey, 1962).

Predictive Values

As a general rule, if one diagnoses cardiac enlargement from a displaced PMI, one expects to find an enlarged heart shadow on the posteroanterior (PA) chest film, according to the Ungerleider–Gubner or Ungerleider–Clark criteria (Ungerleider and Clark, 1939; Ungerleider and Gubner, 1942). In 14 of 16 cases, there was perfect concordance between the presence (or absence) of a displaced PMI and the presence (or absence) of severe left ventricular enlargement on the chest film (Beilin and Mounsey, 1962). In a later study, apex displacement lateral to the midclavicular line (if the PMI was palpable), compared with a radiographic cardiothoracic index greater than 50%, had a sensitivity for cardiomegaly of 59%, a specificity of 76%, a positive PV of 59%, and a negative PV of 77% (O'Neil et al., 1989).

The positive PV of a PMI lateral to the midclavicular line with the patient supine is stated to be a bit over 50% for detecting an echocardiographically enlarged VEDV (Eilen et al., 1983). However, this study was possibly flawed because a single upper limit of normal for VEDV was applied to all 41 subjects regardless of body size; such a procrustean judgment is at variance with biologic measurement.

Is the PMI a Normal Finding?

Dr Phibbs of Arizona believes that the PMI has been misrepresented as a normal finding for years. He states that with normal body habitus, you should not be able to feel a PMI in the supine position, although you can often feel an impulse in the left-lateral decubitus position, especially in slender patients. *Any sustained or complex motion palpable on the precordium signifies a malfunctioning heart* (B.P. Phibbs, *personal communication*, 2004).

Right Ventricular Taps

The *left* parasternal border should be palpated for a *right* ventricular impulse, called *a right ventricular tap, bulge, lift, or heave*. It is different from the subxiphoid point of maximal impulse found in patients with chronic obstructive lung disease, although it may be found concurrently if such patients also have acquired right ventricular hypertrophy. It is nondiagnostic in that it may result from any etiology of right ventricular hypertrophy.

A Method

Place the ulnar edge of your right hand at the patient's *left* parasternal border, touching the third, fourth, and fifth interspaces. A systolic tap (moving your hand) is never felt in normal persons.

For the Attending: A Rounding Ploy. Sometimes a right ventricular tap can be evoked by the same trick used for bringing out an evanescent right-sided gallop: ask the team to elevate the patient's legs (passively) so as to increase right ventricular inflow abruptly.

Interpretation

A forceful, sustained impulse in the left parasternal area usually means right ventricular hypertrophy, pulmonary hypertension, or right ventricular dysfunction. A quick, nonsustained impulse, imparting a slapping sensation to the hand, may result from volume overload of the right ventricle, as from an atrial septal defect. Such impulses may also be present in high-output states such as anemia, anxiety, and thyrotoxicosis (Ewy, 1972).

Caveats

Two common pitfalls may lead the unwary to overdiagnose right ventricular hypertrophy: a normal small midline heart and mitral insufficiency. With the first, the left ventricle and the impulse can be moved from the parasternal area by turning the patient into the left-lateral position (Ewy, 1972).

Ventricular Dyskinesia and Ventricular Aneurysms

Anterior ventricular dyskinesia may occasionally present as a palpable paradoxic (systolic) outward bulge. Previously, these were

all thought to be ventricular aneurysms, but it is now realized that most of them are actually dyskinetic segments, indicative of locally impaired cardiac function, usually subsequent to ischemic heart disease. The pulsations resemble the apical PMI but are usually much more medial. Additionally, they are usually larger than the normal PMI and usually more sustained, not having the acute tapping or "kicking" quality of the normal impulse.

Ventricular aneurysms, when palpable, may produce a systolic impulse or they may cause a diastolic bulge. In the latter instance, the blood enters the heart during early or late rapid filling and causes the thin-walled, nonmuscular aneurysm to bulge, striking the chest wall. This finding may mimic a palpable S3 or S4, except there is no audible gallop.

A forceful lift in what some call the ectopic area, the midclavicular line in the third to fourth interspaces, is a strong indication of a ventricular aneurysm (B.P. Phibbs, *personal communication*, 2004).

Thrills

A thrill is a continuous (i.e., noninstantaneous) palpable vibration. (A thrill lasts longer than the most prolonged PMI.) Thrills accompany murmurs and are the palpable counterparts of turbulence. One might put it, "A thrill is a murmur you can also hear with your fingers." Innocent murmurs do not have thrills. Additionally, the thrill distinguishes grade 4 and above murmurs (which have thrills) from grade 3 murmurs (which do not have thrills) in the intensity scoring system that is presented later.

Other Palpatory Findings

1. A systolic pulsation at the second or third interspace at the left sternal border suggests *pulmonary* hypertension, either primary or secondary, as in atrial septal defect, valvular pulmonic stenosis with poststenotic dilation, dissecting aneurysm, or partial anomalous pulmonary venous return, in that order. Sometimes there is also a palpable valve closure or a diastolic thrill in the case of dissection.
2. If there is a systolic impulse at the first or second right interspace at the sternal border, one should consider an aneurysm of the ascending aorta, aortic insufficiency (because of the large stroke volume being ejected into the dilated aortic root), aortic stenosis with poststenotic dilation, a right-sided aortic arch, or simply a senescent and tortuous innominate artery (Hurst and Schlant, 1972).
3. If there is a systolic pulsation in the retrosternal notch, think of an aortic aneurysm.
4. An impulse occurring immediately *after* S1 may result from systolic expansion of the dilated atria in mitral or tricuspid insufficiency. It is felt at a higher (more toward the base) level than the apical PMI.
5. Patients with tricuspid insufficiency, restrictive cardiomyopathy, or constrictive pericarditis occasionally show a marked apical systolic retraction. The last two may also have an abrupt early diastolic rebound, which can be misidentified as an abnormal systolic pulsation (Stapleton and Groves, 1971).
6. Occasionally a hyperkinetic but otherwise normal heart may show an early diastolic left parasternal rebound, which can be mistaken for a right ventricular tap if not timed correctly.
7. Some S3s are palpable, but S3s are significant even if only audible.
8. A palpable S4 over the ventricle (which is more significant than an audible but impalpable S4; see later in this chapter) will occur just *before* S1. It signifies decreased compliance of the ventricle of origin, as from ischemic heart disease or increased afterload (due to arterial or pulmonary hypertension, or aortic or pulmonic stenosis). Methods for distinguishing right- and left-sided S4s are discussed later in this chapter. Be sure to include palpation with the patient in the left-lateral decubitus position when checking for an S4.
9. About 23% of pericardial friction rubs are palpable.

Percussion

A Pedagogic Note

The suggestion that medical students can learn to percuss the cardiac border accurately is met with general incredulity these days. (By "accurately," I mean with reasonable confidence in their ability to distinguish patients who clearly do not have an enlarged heart from those who do, before looking at the chest film.) (This excludes the morbidly obese patient, who in essence is percussed while wearing an overcoat of cellular triglyceride.)

Admittedly, there is a body of experience, some published, indicating that there are persons who cannot percuss the cardiac border accurately. Similarly, there are persons who cannot play the violin, but that does not mean the violin cannot be played. Scientific studies have shown that in the hands of competent clinicians, the average error of percussion is about 1 cm (Kurtz and White, 1928; Mainland et al., 1938). The largest reported errors, up to 3 cm, occurred in patients with emphysema (McGee, 1995). In a series of 333 comparative measurements in men and 55 in women, using direct light percussion with the patient's chest vertical, 88% of the measurements by percussion were within 15% of the radiographic measurement. In 89%, the difference in measurements was less than 2.0 cm, and in 58%, less than 1.0 cm. The authors of the last study also made the practical observation that "from the standpoint of the consultant, the procedure of direct percussion of the cardiac diameters is the most impressive to the patient and the family. It is one procedure in physical examination which the family physician has not performed already!" (Stroud et al., 1948).

A recent study showed that light, indirect percussion in the fifth intercostal space with the patient supine could reliably exclude cardiomegaly, using a cutoff of 10.5 cm to the left of the midsternal line. The authors commented that medical students, after a brief period of instruction, could percuss as accurately as their mentors (Heckerling et al., 1991).

A cardiologist overheard me talking to a salesman about putting in some shelves for stereo equipment. When he asked about stud placement for putting up the shelf brackets, I told him I would locate them by percussion. The cardiologist made fun of percussion, saying that there was an error of 1 cm.

"You're right." I said, thinking he meant the heart borders.

"Well," he said, "you'd better drill a hole to be sure."

"Oh, I thought you meant the heart borders. I'll get the middle of the studs exactly right."

He said it could not be done, but I have done all my shelf brackets that way.

An Historic Note

In 1899, Francis Henry Williams compared heart sizes as determined by percussion, with the findings on chest radiography, a new technique at the time, and also with the weight of the heart measured in 546 autopsies. He excluded cases of emphysema or "stoutness," "in which percussion is at a great disadvantage." He found that when the heart was approximately normal, error made by percussion was least frequent. When the heart size was smaller than normal, error was very frequent. And when the heart was enlarged, percussive error was less frequent but greater in magnitude (Jarcho, 1969).

Percussion as a Way of Life

A primate called the *aye-aye* (*Daubentonia madagascariensis*), found only on the island of Madagascar, is totally dependent on percussion to find its food, which consists of insect larvae burrowing beneath the bark of trees. Having precisely located the burrow by percussion, the animal sticks a long, spindly third digit into it and scoops out its prey (Short, 1995).

For the Attending. The heart contains no gas and is surrounded by the most resonant part of the body. If it were not possible to percuss the outline of such a structure, then we should also abandon percussion of the lungs for infiltrates and of the acoustically less contrasted organs such as the liver. By direct count over a decade, the number of errors I made in percussing the heart borders was fewer than the number of chest films that had been misplaced by the radiology file room. Accordingly, I encourage the teaching of this technique, which, after an initial investment, is quick, accessible, and reasonably accurate.

A Method

The percussion note is produced in the same manner as described for the lung fields (see Chapter 16). For the beginning student, probably the simplest method is to percuss in the interspaces, following the interspace from its lateral (resonant) area to the medial (dull) area. Begin with the patient's left apical heart border, proceeding superiorly and then repeating the procedure for the right border.

Some excellent examiners percuss in lines or strips perpendicular to the longitudinal axis of the body, moving across interspaces and ribs. They are experienced and can adjust for the changing percussion note of the rib and the intercostal muscle, but this technique is not suggested for the sophomore. Other experienced examiners percuss along lines perpendicular to the anticipated heart borders, but such anticipation is based on experience and is also not recommended for the novice.

When you percuss, you may wish to back up over the border, percussing in reverse from dullness back to resonance as a double check. Dullness is the first detectable tone of impaired resonance obtained when moving from the resonant lung to the cardiac border (or from the resonant lung to the hepatic border). Flatness is the tone of maximally impaired resonance, usually, but not always, located in the middle of the cardiac silhouette (or in the middle of the liver, again, usually but not always). To hear true flatness, percuss your tibia.

Notice that many times the experienced percussor will strike two blows, a hard one and a soft one. They seem to learn to do this unconsciously, and I have never seen the exact reason written down but suspect there must be some sensory information obtained from the difference in the vibrations between the strong and the soft note.

Probably, any system works if it is used consistently. One must gain sufficient experience with the method, frequently correlating the observations with the PA chest film. All normal radiologic values for heart size are based on a PA projection, which is made by placing the front of the chest against the plate with the beam generator behind the patient. The advantage of this technique is that the heart size is not much magnified. However, when a patient is too ill to travel to the radiology department, one generally obtains an anteroposterior (AP) film, wherein the plate is held behind the patient, who is held up in bed, the beam coming from the portable beam generator at the foot of the bed (or if the patient is restrained in bed, one might place the plate underneath him and direct the beam downward)—except in the rare instance in which someone has insisted on obtaining a PA film as described in Chapter 16. On the AP film, the apparent heart size is artifactually enlarged. (Worse, in some hospitals, it is not possible to tell which technique was used.)

Although we now use indirect (mediate) percussion, there were formerly several schools of direct (immediate) percussion. Direct percussion is sometimes better than indirect percussion when it comes to outlining the frontal projection of cardiac dullness, especially in thick-chested patients.

One method is as follows:

1. Use the same routes as for indirect percussion.
2. Using only the fleshy pulp of the middle finger of the right hand, slap the chest wall. Maximal excursion is required to produce a resonant sound.
3. After striking the chest, keep the flesh of the finger applied to the chest wall. For some reason, this seems to improve the technique, possibly because part of percussion involves the appreciation of vibratory dampening.

A second technique is to use the same method as above but stroke the chest wall for a short distance after striking it. The original description and rationale are as follows. There is no sharp boundary between the heart and the surrounding lung. From the upper and left borders, the lung encroaches over the precordial area as a wedge-shaped body. If the examiner is to define the border of the heart, he must employ the smallest pleximeter area and at the same time he must be able to penetrate the overlying lung to detect the resistant heart that lies beneath. Direct or immediate percussion best serves these purposes. The stroke should be made with the palmar surface of the terminal phalanx of the extended middle finger or ring finger. The blow should be made by firmly stroking the heart as if the examiner was seeking to penetrate the underlying tongue of the lung. One should not imitate the stroke of a piano hammer, which is made with a quick recoil to prevent damping of the string. The object of the firmly applied stroke is to damp the thoracic wall and as far as possible eliminate it from sharing in the plexiimeter (Hoover, 1920).

When using direct percussion, one only strikes the chest a single blow.

Locating the Apex

The lower portion of the left border of cardiac dullness is called the *apex*. This border shifts laterally in left ventricular enlargement and pericardial effusion (if massive).

Left Ventricular End-Diastolic Volume and Mass

Increased LVEDV and LVM are predictors of cardiovascular morbidity and mortality. Radiographic cardiomegaly is only weakly correlated with these factors. Using ultrafast computed tomography of the heart, it has been shown that percussion is a reliable method for excluding increased LVEDV and LVM (Heckerling et al., 1993). This study used indirect percussion in the supine position to determine the dullness distance from the midsternal line in the fifth and sixth intercostal spaces. The upper limit of normal was defined to be 10.5 cm. For the combined diagnosis of an increase in LVEDV or LVM, an increased dullness distance had a sensitivity of 91% and a specificity of 30%. (Note, however, that these values are based on only 17 patients with increased LVEDV and 8 with increased LVM out of the 103 who were examined.)

Self-study

In a population with a prevalence of disease of 26%, what is the PV of a negative test? A positive test? What conclusion can you draw regarding the usefulness of the test? (Answers in Appendix 17.2.)

False Positives

Rarely, the left border may be shifted because of the disease of the right ventricle, but only if the right ventricle has undergone massive hypertrophy and enlargement. This may be caused by a condition of systolic overload (e.g., pulmonary hypertension or pulmonic stenosis) or of diastolic overload (e.g., chronic severe tricuspid insufficiency), resulting in a conversion of the right ventricle, which is normally a flow ventricle, into a pressure ventricle. Or it may be shifted from atelectasis of the left lung (see Chapter 16).

Left Ventricular Enlargement versus Massive Pericardial Effusion

In left ventricular enlargement, the PMI will be palpated just within the border of cardiac dullness (partly because the PMI is palpated in systole and the heart border is percussed in diastole, the longer phase of the cycle). In the case of pericardial effusion, the PMI stays where it was, the area of dullness alone being shifted leftward owing to the fluid. Accordingly, the PMI, if palpable, will either be well within the border of cardiac dullness, or it will be obscured by the fluid, and hence not palpable.

A Digression on Pericardiocentesis[2]

Pericardiocentesis was first performed by the Viennese surgeon Franz Schuh in 1840, via the apical approach, before the roentgenogram was invented (Spodick, 1985). In Schuh's method, the needle is inserted 1 cm medial to the apex and aimed at the right sternoclavicular joint. Because there are no large vessels at the apex, there is no danger of rupturing them via this approach.

In 1896, the subxiphoid approach was introduced by Marfan, supplanting Schuh's method. Marfan's approach carries a grave risk of perforating the coronary arteries and veins. The customary procedure of clamping the needle to the exploring electrode of a running electrocardiograph machine does not warn of impending laceration of the vessels, but only retrospects the injury currents due to hitting the myocardium or the Q wave seen after accidentally entering the ventricular cavity. Monitoring the procedure with ultrasound still does not protect the blood vessels; medical house staff have thus become reluctant to perform such a pericardiocentesis without the cardiac surgeons available for backup, and surgeons have begun to take over the procedure entirely.

Schuh's method is still available to those who are able to locate the cardiac apex by percussion. In case of doubt, one could also obtain a chest film with a paper clip taped to the patient's chest at the percussed apical dullness, near the intended insertion point. Roentgenography was unavailable during the first five decades in which pericardiocentesis was performed; this demonstrates the accuracy of percussion in the hands of some.

Upper Left Cardiac Border

The upper portion of the patient's left cardiac border of dullness includes the pulmonic outflow tract. In some cases of severe pulmonary hypertension, one can, with practice, find an outbulging of the cardiac dullness silhouette at the second and/or third left interspace parasternally, unaccompanied by any alteration in the lower left border. (Associated palpatory findings are discussed previously in this chapter.)

The finding of a percussible (and/or palpable) pulmonary artery is not very sensitive. However, there are few false positives (lung tumor contiguous to the heart border, aneurysm of a right-sided aorta, etc.), so a positive test implies one of a limited number of pathologic explanations.

Right Cardiac Border

Boring as it may seem, it is necessary to percuss the right cardiac border to estimate width. If the left border is percussed well inside the usual area (which one can identify because of having percussed the border in many normals), one might not know how to interpret the finding without also percussing out the right border. One could be dealing with the vertical or "drop" heart (so named because it resembles a water drop in shape) or with a shift of the mediastinum to the right (usually due to atelectasis of the right lung, in which case the trachea will usually be shifted—see Chapter 16). This is an important differential because the former usually signifies pulmonary emphysema (or rarely hypovolemia, especially of the chronic variety as in Addison disease), while the latter points to other diseases of the lung.

Other Uses of Percussion

The right cardiac contour, unfortunately, is not the right ventricle, which has no representation in the frontal projection, either of cardiac dullness or the chest film. However, right ventricular enlargement causes a flat percussion note, replacing the usual dull sternal percussion note beginning about 3 cm above the xiphoid.

[2] Also see the epigram to this chapter for a French claim to the first pericardiocentesis.

(Below this, flatness might be caused by the liver.) The higher the flatness extends, the more likely that its cause may be a pericardial effusion rather than right ventricular enlargement (Moschcowitz, 1933). For another method of outlining the cardiac profile, see the scratch test later in this chapter.

Dullness from the manubrium over to the third costal cartilage on the right is seen in aneurysm of the arch of the aorta and is called the *Potain sign*.

For the Virtuoso. Perloff suggests locating gastric tympany prior to cardiac percussion, for the purpose of determining visceral *situs inversus*. If there is insufficient air in the stomach to permit distinction of liver dullness from gastric tympany, Perloff suggests that the patient be instructed to inhale and swallow a few times, to induce aerophagia. Alternately, he could drink a carbonated beverage.

In case of failure of full diaphragmatic descent due to either paralysis or atelectasis of the ipsilateral lung, the inspiratory intrapleural pressure on the impaired side will be higher (less negative) than on the other side. Thus, during inspiration, the mediastinum will move away from the affected side (Macklem, 1986). I have no experience with this method and suspect it would be easier to detect impaired diaphragmatic descent first by the Hoover sign, and then to percuss the hemidiaphragms individually to see whether either had paradoxic motion.

Heart Failure without Cardiomegaly

Inspection, palpation, and percussion are all techniques to help reveal cardiac enlargement, an important sign of heart failure. Some patients erroneously thought to be in congestive heart failure will have a normal-sized heart by any method of mensuration. This set comprises constrictive pericarditis, tricuspid stenosis, inferior vena cava obstruction, pulmonary vein thrombosis, mitral stenosis, diastolic filling dysfunction, and ischemic (coronary artery) heart disease.

Auscultation

Question: *Why could Laënnec detect the sounds of the heart better with his rolled-up quire of paper (see Chapter 1) than with the application of his hand?*

Answer: *See Appendix 17.3 (and Fig. 17-15).*

In cardiac auscultation, even more than in other aspects of clinical examination, *die Methode ist alles*.[3] Auscultation is like a front-end-loaded mutual fund. It initially takes a great deal of time to master the technique, even in the present era, when heart-sound simulators and cardiac-sound recordings (such as Stein and Delman, 1997) can provide a medical student with a lifetime of experience in just a few months.

Unfortunately, most modern medical "educators" place less emphasis on the rudiments of the physical examination than on learning to prescribe for diseases that the students cannot even spell let alone diagnose. However, in the 30 years spent both in the trenches and rear headquarters, I have seen the treatment of disease change more often than a pedestrian crossing sign, whereas the semeiophysiology is as constant as taxation. Therefore, remember that once you know the correct diagnosis, you can always look up the treatment in a current textbook, but if you do not have the correct diagnosis, a chain of drugstores will be needed to provide enough medication to cover all the possibilities.

A Reminder for Sophomores. Again, be sure that the stethoscope earpieces are comfortable and are pointing forward when you place them in your auditory canals. Before you begin listening, tap the chest piece with your finger to be sure that it is "on line." If you are still having trouble hearing things that others can hear, check your stethoscope. Are the earpieces large enough? (Small ones can be occluded by the bony canal.) Is it clean and in good repair? (Dirt and cracked tubing can degrade accuracy.)

Dr Campbell Moses of New York taught me that at the beginning of the auscultation of the heart, the patient should be told: "I may listen to your heart for a long time. That doesn't mean I'm hearing anything bad." Remember that the patient will be observing your facial expressions but that you will not be attending to his responses, as you concentrate on what you are auscultating.

Much has been written about the technique of "inching" (*vide infra*), the type of stethoscope that should be used, the importance of phonocardiography, ancillary aids such as amyl nitrite, and the various phases of the Valsalva maneuver. However, there are, in my view, only two issues that are critical to learning cardiac auscultation.

Rule 1: You must listen in a completely quiet room. The reason should be clear from Table 17.1. In practice, this means turning off the television, turning off the radio, closing the door, closing the windows, removing all visitors from the room, and, in some cases, silencing thoughtless colleagues and superiors whose mumbling will interfere with your auscultation. There is *no substitute* for quiet.

A Self-study. Have your partner stand 4 ft away and whisper a number (e.g., his Social Security number). According to Table 17.1, that is 20 dB. It is also much easier to hear than the average murmur of aortic or pulmonic insufficiency.

Now go into a nurse's station ("an average office") and repeat the experiment. Can you still identify a whispered 9-digit number (different from the first one)? About how many decibels were ambient? Repeat the experiment 3 ft from an ordinary conversation. Can you still hear all the numbers? How many decibels were ambient?

At what location could you no longer pick up the whispered signal of 20 dB? Is the average ward in your hospital louder or softer than that? How then could you possibly hear aortic or pulmonic insufficiency, which are even softer than 20 dB?

Question: *What can you do when the room is completely quiet, but you still cannot hear well*[4] *because the patient has his own noise generator, say the coarse rhonchi of obstructive pulmonary disease, or loud wheezes that obscure both the heart sounds and any murmur less than grade 4?*

Answer: *State the absence of meaningful data by noting in the record that you were unable to auscultate the heart sounds. However, once the patient is quiet, you are obliged to return and complete the physical examination, even if it was begun several days earlier.*

[3] "The method is everything." This was supposedly the watchword of Emil Fischer and the other great *fin de siecle* German organic chemists. Now that polypeptide synthesis has been automated, I suggest appropriating their motto for clinical examination.

[4] Auscult bony chests by placing a 150-mL plastic infusion bag on the chest and a stethoscope on the bag (Perry et al., 1984).

TABLE **17.1** *Levels of noise from common sources*

Source of noise	Distance from source (ft)	Noise level	
		Decibels[a]	Amplitude ratio
Ordinary conversion	3	65	1778
Average office	—	47	223.9
Average whisper	4	20	10.0
Threshold of hearing	—	0	1.0

[a] For a definition of decibels, see Chapter 11.
From Rappaport MB, Sprague HB. Physiologic and physical laws that govern auscultation. *Am Heart J.* 1941;21:258–318, with permission.

Rule 2: Listen to one time at a time. That is, listen to only one part of the cardiac cycle at a time. You must first make sure you have identified systole and diastole (*vide infra*), but just this is not sufficient. Remember the rule of two diastoles (see Chapter 4).

The murmurs of pulmonic insufficiency and aortic insufficiency can only be heard by concentrating one's attention in the early portion of diastole. Other auscultatory phenomena (e.g., a ventricular gallop, an opening snap) are also heard only in this brief time interval. To hear this portion of diastole, you must learn to listen to the space just after the second heart sound to the exclusion of all else.

Other auscultatory phenomena (e.g., atrial gallops) are heard specifically in late diastole, just before the first heart sound. To hear them, concentrate only on the first heart sound and then when you know it's coming, listen only to the space just before it. (This is like catching the brass ring on the merry-go-round.)

If you do not systematically search through the three time intervals (systole, early diastole, and late diastole), excluding your attention from the other two intervals in turn, you will miss many important findings. If you miss a murmur because you are not listening to one phase at a time, it is not appropriate to say, "Some people can hear it and some people can't." Murmurs are either present or absent. The murmur is not a Zen koan about a tree falling in an uninhabited forest. It is a finding accessible to competent examiners, if they are listening in a quiet room and if they know what they are listening for. (Admittedly, some findings are present intermittently. Also, there are some people who say they heard something they thought they were supposed to hear, even though they did not actually hear it. Intellectual honesty is always required.)

Once you are well acquainted with the sound of various findings, you can "tune in" to listen for them. As one physician explained, "If your daughter is a piccolo player in the orchestra, you can recognize her instantly because you are listening for her playing, whereas others will not" (Cheng, 1997).

For the Attending. With the heart-sound simulator, first, play a soft murmur or sound that the student cannot hear. Next, play a loud version of the same thing; then decrease the gain successively. Finally, present the same murmur at different places in the cardiac cycle. In this way, the student learns to hear murmurs that "other persons can't."

Timing the Cardiac Cycle

Do not assume that the timing of the cardiac cycle is obvious. You must make a positive identification of the first heart sound, by palpating the PMI or auscultating at the apex where S1 will usually be the loudest sound. Unfortunately, many patients will not have a palpable PMI, and in some conditions (e.g., first-degree heart block), S1 will be diminished, even at the apex. In cases like these, use the carotid upstroke, which occurs very quickly after the beginning of systole (see Chapter 18 for a detailed discussion of the carotid artery pulse). This is especially helpful when auscultating a patient with a highly chaotic rhythm (e.g., atrial fibrillation with an irregular ventricular response).

For the Attending. Any student may be publicly chastised if he permits himself to be entrapped into attempting to identify a simulated murmur (see later in this chapter) as systolic or diastolic without requiring of the tester the simultaneous presentation of an independent nonacoustic event akin to the carotid artery pulse. It is for this reason that I believe all cardiac sound simulators should be viewed from the beginning, with the simultaneous phonocardiograph and electrocardiograph displayed, not to teach electrocardiography, but to act as an external cue to time sequencing, thus getting the student into the indispensable habit of determining systole from the very beginning.

Any teacher of physical diagnosis who considers this issue to be overemphasized is invited to begin his lecture by playing recordings or heart-sound simulations of several diastolic murmurs. After the students have drawn the murmur shapes, turn off the sound and then ask them to state retrospectively whether each murmur occurred in systole or diastole.

Alternately, ask a seasoned cardiologist what kinds of valvular lesions have been missed at his institution. Aortic insufficiency and to a lesser degree mitral stenosis are frequently signed out as inexplicable cardiomyopathy. Review of the old records may reveal that murmurs ("systolic") have occasionally been recorded, even when the patient had no systolic murmur, but did have a diastolic one.

Traditional Areas of Auscultation

Certain of the precordial areas have, by tradition, been associated with certain cardiac sounds and certain murmurs. (The murmurs themselves are discussed in greater detail later in this chapter.) The definitions to be used in this work are as follows.

The aortic area is the second right interspace at the sternal border. Aortic stenosis murmurs should be loudest here or at the right midclavicle. Formerly, clinicians auscultated in this area for the second heart sound, believing (incorrectly) that the intensity of the entire second sound here was a perfect measure of aortic valve closure. This condemnable practice has been shown to be phonocardiographically unsound (Weisse et al., 1967) and only created confusion about the meaning of the term "A2" (see Chapter 4).

The pulmonic area is the second left interspace at the sternal border. Pulmonic murmurs and murmurs of patent ductus arteriosus should be loudest here. Formerly, clinicians auscultated for the second heart sound in this area in the erroneous belief that they were listening only to the pulmonic component. They incorrectly labeled this sound "P2" (see Chapter 4) and inferred that by comparing it with the intensity of the second sound in the aortic area, they could make some sort of statement about the relative pressure relationships of the right and left circulations. They were often wrong. If one wants to make a statement about these relationships, one must compare the two components of the second sound at the same place, usually the pulmonic area, sometimes at the third left interspace along the sternal border or rarely even at the aortic area.

Together, the aortic and pulmonic areas are referred to as the base. This is supposed to be the base of a triangle whose apex is the PMI.

Despite the classical designation of the "aortic" and "pulmonic" areas, if you look at a heart you will notice that the two valves are right on top of each other, not side by side.

The tricuspid area is in the fifth intercostal space at the left sternal border. This surprises some sophomores who believe that right heart valves should be to the right of the sternum. Well-localized tricuspid murmurs and some murmurs of IHSS are heard here.

The mitral area is just medial to the apex, which is located by palpation and percussion. (Normally, it should be in the fifth intercostal space at the left midclavicular line.) S1 is best heard in this location. Also, one expects to hear mitral murmurs here.

In wide-open mitral insufficiency, the left side of the heart enlarges, and the apex and the mitral valve (in terms of their topical acoustic representations) move laterally, sometimes to the anterior axillary line or beyond. By some books' definitions, the mitral area is supposed to be fixed. *Nondimeno, esso muovo*.[5] Worse, in severe pulmonary hypertension, with the right ventricle converted into a pressure chamber, the right ventricle enlarges, moving slightly leftward. The tricuspid valve, in terms of its topographic representation, moves with it and might eventually move to the original mitral area. Such tricuspid insufficiency can produce a loud holosystolic murmur at the so-called *mitral area*.

Accordingly, I think of the mitral area less as a constant point and more as a metaphysical concept. The description of these areas should not be taken to mean that you should listen only at these points, as some books have suggested. Inching[6] along the sternum and the precordium is also important, especially for determining radiation and the loudest point of a murmur. This technique is also useful for distinguishing the two murmurs that occur in the same time frame, as with the murmur of mitral insufficiency and the coexistent murmur of aortic stenosis. As one inches along, one notes that what was initially thought to be a murmur now displays different pitch and timbre (see "Dimensions," below) in different parts of the chest.

Heart Sounds (S1 and S2)

A Self-study

Figure 17-1 contains some heart sound illustrations. However, they are not marked according to the portion of the text to which they refer. Conversely, the text contains no indication of what narrative portion matches any of these illustrations. Your job is to label the illustrations correctly, write the legends, and indicate in the text which passages are illustrated, by each illustration. You should be able to get some of them on the first reading and the remainder on the second reading. If you cannot, ask for help from a more experienced person.

First Heart Sound (S1)

After auscultating the first heart sound, you should be able to answer three questions: (a) Is the heart sound single or doubled (i.e., split or duplicated)? (b) What is the intensity? and (c) Is it always of the same intensity?

Doubled S1

A widely split or doubled S1 might reflect a delay in closure of the tricuspid valve due to right BBB. In that case, the second heart sound should also be abnormal, with a wide fixed split.

A wider apparent split of S1 could in reality be an S1 followed by an early systolic click S1 (S1-ESC) or an S4 followed by an S1 (S4–S1). To distinguish reliably between these two possibilities requires a phonocardiograph with simultaneous electrocardiographic recording. There is no reliable bedside method (Shaver et al., 1985), although there are clues.

The sequence S1-ESC is known by the company it keeps or rather by the company the ejection click keeps (i.e., one may diagnose S1-ESC by finding evidence of mitral valve prolapse, either a midsystolic murmur, or, if one were very lucky, the characteristic whoop or honk). Sometimes, the first component is so high pitched that one can immediately diagnose S1-ESC because the S4 of S4–S1 could not be so snapping. The suspicion of S1-ESC due to mitral valve prolapse can be confirmed, even in the absence of a murmur, whoop, or honk, by reexamining the patient in the standing versus the recumbent positions. If the second component of the sequence moves earlier in systole (closer to the first sound) when the patient

[5] "Nevertheless, it moves" was Galileo's whispered comment after being forced to recant his theory that the earth moves around the sun. We clinicians honor Galileo, the medical school dropout, not only for his scientific devotion to truth but because he invented the thermometer, which led to Sanctorius and the clinical thermometer; the barometer, which led to Riva-Rocci sphygmomanometer; and the pendulum, which led to Huygens' clock and the rest of the vital signs.

[6] The technique of inching was named by Dr Sam Levine.

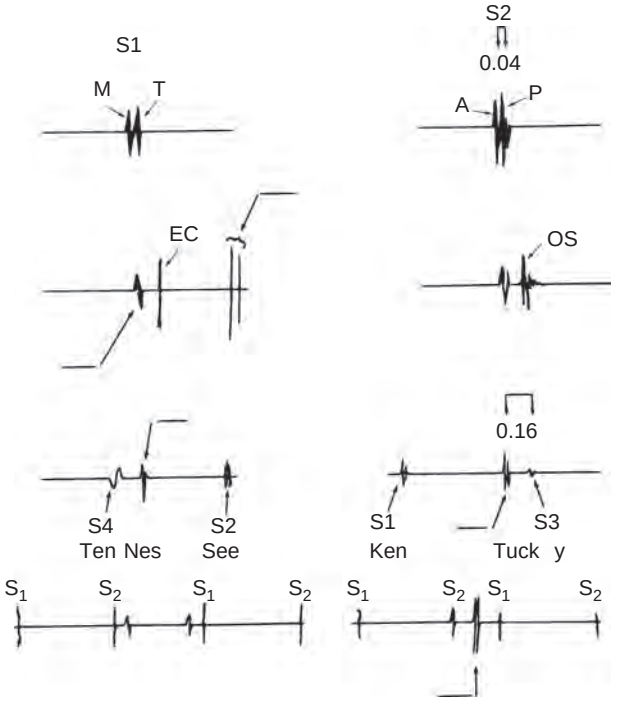


FIGURE 17-1 Diagrams of heart sounds for self-study exercise.

stands, it is highly likely that the two sounds represent S1-ESC. (If the suspected click does not move appreciably, then the maneuver is of no help.)

The other sequence, S4–S1, can sometimes be suggested by the brief, low-pitched rumbling vibrations of the S4. Sometimes, one can palpate a low-frequency vibration (S4) occurring before the second component (S1). To so diagnose the S4 by palpation requires extensive experience with thin patients. S4 may also change according to the maneuvers discussed later in this chapter.

Listening with the bell, with alternate application of lighter and heavier pressure, might be helpful. If the extra sound is an S4, it may be more apparent with light pressure because of its low frequency. If it is an ESC, which is of a higher pitch, it may be better appreciated as pressure turns the bell into a diaphragm.

Intensity of First Heart Sound

Having determined whether the first heart sound is single, one next needs to listen for its intensity, which is usually best appreciated during auscultation near the apex, where S1 is normally louder than S2. If S2 is louder there, one has evidence for either increased amplitude of the second heart sound (usually from an increase in P2; see later in this chapter) or decreased amplitude of S1. The intensity of S1 is primarily related to the degree of separation of the mitral valve leaflets at the onset of left ventricular systole (Shaver et al., 1985). An acoustic physicist could say that the intensity of S1 results from the abruptness of valvular deceleration at closure. A musician could say that the intensity of S1 reflects the vigor with which the mitral valve and tricuspid valve beat shut. A cardiologist, however, might say that the intensity of S1 is a function of the distance that the mitral and tricuspid valves move before they slam shut.

For convenience of discussion, we will subsequently confine ourselves to the mitral valve, which contributes most of the sound in S1. However, all statements also apply to the tricuspid valve.

1. In first-degree heart block, the PR interval is prolonged, so that the mitral valve leaflets have to "wait" an extra few hundredths of a second before the (delayed) ventricular conduction slams them shut. During this delay, they float back toward the closed position, so that when the ventricular conduction finally occurs, they do not have quite so far to go. Thus, they produce a softer-than-usual S1, although S2 will continue to be of its usual intensity. (You might describe the resulting sounds as "lp-dub," rather than the normal "lub-dub.")

   A muffled first heart sound does not always mean first-degree atrioventricular (AV) block.
2. If a failing left ventricle cannot generate much pressure change per unit time, S1 may be muffled even though the sequence of AV conduction is of normal timing. You may already have made this diagnosis by looking at the neck veins, percussing the heart borders, and hearing a ventricular gallop. However, the left ventricular failure—possibly due to damage from ischemia, infarction, or aneurysm—is not always florid enough to have produced those other signs.

   Other causes of a decrease in amplitude of S1 include
3. Left ventricular hypertrophy (Luisada and Portaluppi, 1983);
4. Left BBB (Luisada and Puppala, 1979);
5. Impaired apposition of the valves, as in mitral insufficiency. Points 3 to 5 may be distinguished by the prolonged or displaced PMI, paradoxic splitting of S2, and the characteristic murmur, respectively.
6. A muffled S1 due to asynergy of closure of the mitral and tricuspid valves need not result from a BBB; an intraventricular conduction delay may suffice. This demonstrates the value of the electrocardiogram.
7. Hypertensive patients with normal PR intervals often have a soft S1 (Shaver et al., 1985).

An abnormal *increase* in the amplitude of S1 may occur in mitral stenosis (which is associated with a characteristic murmur) or hyperkinesis (as after vigorous exercise, excitement, exposure to a stressor, or high-output failure, discussed later in this chapter). A booming S1 with after vibrations has been noted in one patient with a left atrial myxoma (Shaver et al., 1985). A recent study found that a loud S1 heard over the apex in patients with nonrheumatic mitral regurgitation is indicative of holosystolic mitral prolapse. Patients with the more common middle-to-late systolic prolapse have a normal S1 (Shaver et al., 1985).

Variable Intensity of First Heart Sound

Besides comparing the intensity of a normally louder apical S1 with a normally softer apical S2, it is important to listen for beat-to-beat variations in S1, again best done at the apex in most cases.

Second-degree heart block of Mobitz type I (but not of Mobitz type II) and third-degree heart block cause such a beat-to-beat variation. In Mobitz type I heart block (see Chapter 6), each successive PR interval is increased until the skipped beat occurs. This causes a gradual diminution of intensity of the first, but not the second, heart sound. It may therefore be possible to diagnose second

degree AV block from the missed beat and to specify that the block is of Mobitz type I from the decreasing intensity of S1. The sound may be described like this: LUB-dub, lub-dub, lp-dub, pause, LUB-dub, lub-dub, lp-dub, pause, LUB-dub, lub-dub, lp-dub, pause,… It is easy to note the missed beat of second-degree AV block, but the change in intensity of the first heart sound with Mobitz type I is much more difficult to appreciate.

Musicians may wish to play the score in Fig. 17-2A on a percussion instrument of their choice. The second heart sound is not shown for clarity of expression because it does not change in intensity. The *ritardo* notation indicates a slight slowing, assuming the atrial rate to be the metronome. The *decrescendo* mark indicates the increasing softness of the S1 in each series.

The score for the first heart sound in Mobitz type II (see Chapter 6) is musically much simpler (Fig. 17-2B) but clinically much more ominous. Because there is no prolongation of the PR interval before the dropped beat, there is no change in intensity of S1, and the sounds might be described thus: lub-dub, lub-dub, lub-dub, lub-dub, pause, lub-dub, lub-dub, lub-dub, lub-dub, pause…. In third-degree heart block, none of the atrial impulses reach the ventricles. The atria beat regularly at their own rate, and the ventricles beat regularly at their own rate determined by the "escape" pacemaker (located in the AV node or lower). The atrial contraction (assuming that the atria are not fibrillating) continues to open the mitral (and tricuspid) valve widely. The ventricular contraction, occurring at an unrelated rate, closes the valves. However, this random contraction may catch the AV valves at maximum excursion and slam them shut, producing a very loud sound, or randomly, at minimal excursion, there will be a very soft sound. The variable intensity of S1, with normal S2, might be described thus: lub-dub, lp-dub, LUB-dub, Lub-dub, LUB-dub, lp-dub, Lub-dub,….

Musicians may wish to play "third-degree heart block" (Fig. 17-2C), which is scored for both heart sounds. However, S2 is of the same intensity throughout and may be ignored while auscultating for S1. S1 varies across the dynamic register. Note that the score is marked *largo*, to be played very slowly.

In fact, the only bradycardia with a variable S1 is the third-degree heart block. Of course, a variable S1 may be heard in other forms of AV dissociation, but these will not produce a regular bradycardia. Although one might argue that third-degree heart block is best diagnosed with an electrocardiogram, there is still a place for bedside diagnosis, even in patients who are being electrocardiographically monitored; for example, some of the intensivists' unique and novel precordial leads are placed near the acromioclavicular joints and are not truly precordial exploring leads but rather modified versions of lead I. If these are arranged so as to be perpendicular to the long axis of the P vector loop, the scalar P waves may be difficult to detect. On at least one occasion, it was possible to diagnose third-degree heart block by auscultating the patient while the beard-scratchers were puzzling over just such an afflictive tracing and debating rearrangement of the leads.

Very Advanced. For pedagogic purposes, we have been speaking as if the heart sounds were produced by the valves clanging shut. However, Luisada believes that the heart sounds are really caused by accelerations and decelerations of the "cardiohemic" system (the column of blood moving in relation to the heart and vessels [Luisada and Portaluppi, 1983]).

Ordinarily, the accelerations and decelerations correlate in time with the valve events (although this is not always the case). Although the cardiohemic theory does agree with the empiric observations, there is a scientific rebuttal available (Dock, 1980).

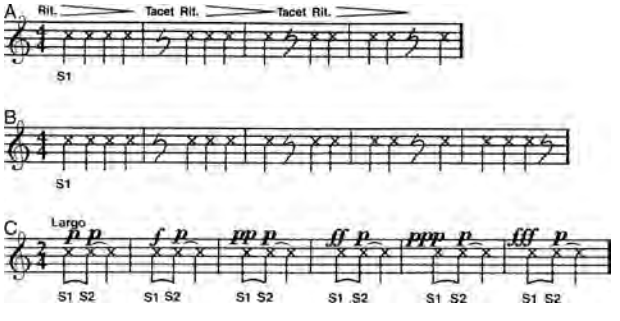


Figure 17-2 Musical scores for the first heart sounds in Mobitz type I second-degree arteriovenous (AV) block **(A)** and Mobitz type II second degree AV block **(B)** and for both heart sounds in third-degree heart block **(C)**.

Second Heart Sound (S2)

Amplitude of Second Heart Sound

At the base, the collective S2 (A2 and P2 together) should be louder than S1. If it is not, something is different from normal.

Splitting of Second Heart Sound

Normally, S2 is "split" during inspiration, and less so during expiration; this is known as "normal splitting." However, this phenomenon is not detectable in many normal persons. (*Historical note:* The normal inspiratory splitting of S2 was first described in 1866 by Potain [Leatham, 1954].)

The various types of splitting are diagrammed in Fig. 17-3, to which you should refer while reading the discussions that follow.

The splitting is most likely to be found in the second or third left intercostal space, so these are the best places to *start* your search. Contrary to expert opinion, the splitting is not *always* most apparent there (Sainani et al., 1967).

Auscultation for splitting of S2 is useful for two reasons. First, if the splitting is not normal, this is a free clue to the existence of a small number of pathologic explanations. Second, even if the

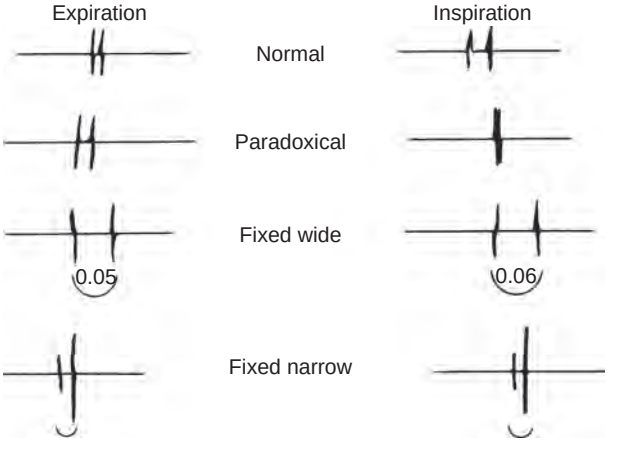


Figure 17-3 S2 splitting.

splitting is normal, the comparative intensities of the aortic (A2) and pulmonic (P2) components may often be useful information.

The novice needs to be aware that initially S2 will not seem to have two distinct components but rather just a prolongation. One can learn this best with a heart-sound simulator, which allows the A2–P2 interval to be mechanically varied. Alternately, or additionally, one can practice by tapping one's index and third finger on a hard surface, first simultaneously, and then with one finger slightly after the other. In the latter situation, one can appreciate that two disparate events (the fingers tapping the desk) are felt as separate, but initially heard as one sound. With increasing intervals between the two taps, the sound becomes "longer" in duration; only when very wide temporal intervals are attained does one actually hear a splitting into two distinct components. The latter is itself a sign of pathology in an adult (not in a child): if initially you can easily hear S2 split into two distinct sounds, you are probably hearing an abnormally wide split (0.06 second or more) or a second heart sound followed either by a third heart sound or an opening snap.

A further problem with this psychoacoustic event is that the second component (P2) is often softer than the first component. Unfortunately, a soft sound following a loud sound is more difficult to appreciate as a separate event than a loud sound following a soft sound with the same interval of separation. (This too can best be learned with a heart-sound simulator.) Failure of the beginner to realize that the "split" is at first a learned perception, not an easily apparent auscultatory event, is partly responsible for not using the convenient information that can thus be obtained.

Semeiophysiology

The relatively negative intrathoracic pressure produced during inspiration sucks the blood into the right (but not the left) heart in excess of that which arrives during the expiratory phase. This extra blood results in a slightly increased right (but not left) ventricular ejection time. (It takes longer to empty an overcrowded elevator than one that is simply full.) The slight delay in the subsequent pulmonic closure sound produces splitting.

A second explanation for the normal delay in pulmonic closure during inspiration is that the capacitance of the pulmonary vasculature (but not of the systemic vasculature) is increased during inspiration. Thus, there is less left ventricular filling. This in turn shortens the left ventricular ejection time (LVET) (vis-à-vis that of the right), and so the A2 sound comes even earlier than usual, thus widening the split, compared with the split in expiration (Curtiss et al., 1975). Note that the two explanations are not mutually exclusive and may both be operational.

A Method

Because the splitting is produced by the dynamic events in the chest, one cannot listen for splitting in held inspiration or held expiration (cf. "Pulsus Paradoxus," Chapter 6). Those maneuvers will simply abolish the change. The patient must rather continue to breathe while one listens.

1. First listen only to those S2s that occur during expiration. Ignore anything that you hear during inspiration until you have a clear mental picture of the (baseline) S2 in expiration again. This will not be a mental picture of two discrete events as pictured in most textbooks, unless there is an abnormality; rather, it is a sound image whose important dimension (at this point) is duration. If you do perceive a split in expiration, then the patient either has fixed splitting of S2, paradoxic splitting of S2, or a normal S2 followed by an extra sound. The differential diagnosis of all of these is discussed later in this chapter.
2. After you have a clear mental image of the expiratory S2, switch your acoustic attention to S2 in mid-to-end inspiration. It may be necessary to listen through several respiratory cycles. When you are first learning this technique, it may take so many respiratory cycles to develop a mental image of the inspiratory S2 that you may have forgotten what the expiratory baseline (S2) sounded like. In that case, switch back to the expiratory phase and listen again. The question you must finally answer is this: Are the inspiratory S2s longer than the expiratory ones? If so, S2 is said to be normally split and you should proceed to "Relative Intensity of A2 and P2," discussed just below. If not, go to "Paradoxical Splitting," discussed later in this chapter.

Further Considerations on the Second Heart Sound

1. It is easier to hear the normally split second heart sound in the upright position because upright posture exaggerates most respiratory effects (unless there has been considerable cardiac failure). (Contributed by Dr David Spodick of Massachusetts.)
2. As the student becomes more experienced, he will begin to identify readily longer and shorter second heart sounds. Next, he will find that he can actually begin to hear the inspiratory split. That is, he can actually hear two components to the split second sound, whereas before he could only hear a "long" sound, but could not clearly identify the two components. When this happens to the student, he will begin to appreciate for the first time that there are many perfectly normal persons with *distinctly* split second heart sounds, although the interval is normal. This is not a sign of increased prevalence of disease in one's classmates, but of improved skills.

Relative Intensity of A2 and P2

Once you have determined that S2 is normally split, you should compare the two components. This can usually be done most easily in inspiration, when the splitting is maximal. Normally, the aortic component (A2) is louder than the pulmonic component (P2), even over the pulmonic area. This produces a sound that musicians call *diminuendo*. You may familiarize yourself with this sound by returning to the finger-tapping exercise, this time striking the first finger much harder than the last. (It may take a little practice to produce the sound you desire.)

Accentuation of the aortic second sound may result from increased back pressure on the aortic valve leaflets, as in arterial hypertension. Sometimes this sound is said to have a tambour quality (like that of a tambourine without the metal discs in the rim). Other causes of an accentuated second sound include aortic insufficiency, coarctation, aneurysm of the ascending aorta, and rarely aortic stenosis (DeGowin, 1965). At other times, the two components of S2 are equal. This can be pathologic, or it may simply mean that your stethoscope is closer to the origin of P2 than to the origin

of A2. This finding needs to be recorded as A2 = P2, but it does not require an immediate explanation.

However, sometimes P2 is clearly louder than A2. The sound here is crescendo. Again, you can practice hearing this sound with the finger-tapping exercise, this time striking the second finger more vigorously. (For those who have played the drums, this will be remembered as the sound of a flam.) If P2 is louder than A2, an explanation is required. Either P2 is abnormally increased (as in pulmonary hypertension) or A2 is decreased (as in calcific or rheumatic aortic stenoses, which decrease the recursion of the aortic valve). In situations in which it is not possible to distinguish A2 from P2 on the basis of a recognizable type of splitting of S2, try inching down the left sternal border. The aortic component normally radiates further than the pulmonic component, so the latter will drop out first in the course of inching away. (This does not work with severe pulmonary hypertension.)

The S2 split is normal during pregnancy, but P2 is often louder, despite a normal pulmonary artery pressure. This has been attributed to increased stroke volume. There is also an increase in intensity and an exaggerated splitting of S1 during pregnancy (O'Rourke et al., 1970).

Single S2

Any condition that delays A2 may produce a "single S2," that is, one in which the splitting interval is less than 0.03 seconds. Also, conditions in which one component of S2 is either absent or inaudible will produce a single S2 (e.g., severe tetralogy of Fallot, severe semilunar valve stenosis, pulmonic valve atresia, most cases of tricuspid valve atresia, and other complex forms of congenital heart disease). However, the most common cause of a single S2 in the general population is the age greater than 50 years. This finding has been attributed to a delayed A2, although a decreased inspiratory delay in P2 has also been reported (Shaver et al., 1985).

Paradoxical Splitting

If S2 is "longer" (i.e., more split) during expiration than inspiration, the splitting is called *paradoxical*. In this instance, A2 and P2 have reversed their sequence: P2 is now first. (*Self-test:* Can you recall the normal order of closure of the heart valves? If you have trouble, the mnemonic is "many things are possible," or "there are more things in heaven and earth, Horatio, than are dreamt of in your philosophy.")

Paradoxical splitting may be caused by anything that causes premature closure of the pulmonic valve, either by selectively shortening the right ventricular ejection time (patent ductus arteriosus with a left-to-right shunt through the ductus or rare cases of tricuspid insufficiency) or, more commonly, by selectively lengthening LVET. The last may result from electrical (such as left BBB) or mechanical causes. Examples of the latter include ischemic heart disease and aortic stenosis (and possibly systemic hypertension). Although relatively minor aortic valve deformities may produce a murmur, paradoxical splitting implies that the stenosis is hemodynamically significant.

1. An additional cause of paradoxical splitting is early electrical activation of the right ventricle in Wolff–Parkinson–White syndrome, type B (Shaver et al., 1985).
2. A patient with left ventricular hypertrophy secondary to aortic stenosis had the latter repaired with a Bjork–Shiley valve, after which the patient still had a paradoxically split S2. Possibly, his LVET was still mechanically prolonged through some combination of fatigued myocardium and the slightly increased afterload caused by the prosthetic valve.
3. Paradoxical splitting is a rare finding in uncomplicated hypertension. The original teaching was that paradoxical splitting of S2 could occur in "systolic" hypertension. I agree that very rarely one can find a paradoxical splitting of S2 in diastolic hypertension. However, because this may result from a prolonged LVET (due to high-resistance systemic circulation into which the stroke volume must be driven), it should relate to increased peripheral vascular resistance, not just to the systolic blood pressure. All things being equal, the systemic vascular resistance will be proportional to the mean arterial blood pressure, which in turn will be closer to the diastolic blood pressure than to the systolic (see the formula in Chapter 6). Thus, the hypertension that causes a paradoxical splitting of S2 should be best described as "systemic" (since it is selective for the greater circulation) rather than "systolic."

Another potential explanation for paradoxical splitting of S2 in systemic hypertension is the cardiomyopathy produced by the chronic hypertension. At first glance, this seems unlikely because cardiomyopathies are usually not accompanied by this finding. However, most cardiomyopathies make the right and left ventricles equally sluggish, whereas hypertensive cardiomyopathy could selectively increase LVET because the precapillary pulmonary vascular resistance is normal, whereas the systemic vascular resistance is increased.

Pseudoparadoxical Splitting

1. Pseudoparadoxical splitting of S2 results from the loss of P2 with inspiration due to the increasing distance of the heart from the stethoscope head, producing a "narrow" S2 of aortic valve-only closure during inspiration and a normal S2 (A2 + P2) during expiration. This is especially likely to occur in patients with severe chronic obstructive lung disease and in those who have a widely split S2 due to delayed closure of the pulmonic valve (so that the split is well heard during expiration) (Shaver et al., 1985).
2. Pseudoparadoxical splitting may also occur in some cases of constrictive pericarditis, in which there is a peculiar splitting of the second heart sound, which is heard only at the beginning of inspiration (Beck et al., 1962).

Wide Fixed Splitting

If the second heart sound is split during both inspiration and expiration, it is said to have a fixed split. A wide fixed split of S2 can result from delayed closure of the pulmonic valve or premature closure of the aortic valve. Delayed closure of the pulmonic valve can be electrical, as in right BBB, or mechanical, from a selectively prolonged right ventricular ejection time. The latter can be from valvular pulmonic stenosis or from selective volume overload of the right heart as in atrial septal defect or partial anomalous pulmonary venous return (also see decreased pulmonary vascular impedance

in Table 17.2). Early closure of the aortic valve may result from a decreased LVET from either mitral insufficiency or a ventricular septal defect with a left-to-right shunt. (The latter also produces volume overload of the right ventricle.)

This sort of split is not always fixed, in the sense of being, say, 0.073 seconds in both inspiration and expiration. However, because the split is very wide, the pulmonic and aortic components never get close enough together to make the normal mushy slurred single sound in expiration that is customarily and easily compared with the more prolonged split in inspiration. Hence, the components of S2 are acoustically "fixed" in a (variably) split position.

The wide split S2 associated with delayed electrical activation of the right ventricle (right BBB) is often accompanied by wide splitting of the first heart sound as well (Shaver et al., 1985).

Wide and often fixed splitting of S2 has been reported in 18 cases of massive pulmonary embolism. This was attributed to a combination of decreased LVET due to diminished stroke output and relatively increased right ventricular ejection time due to a failing right ventricle contracting against increased pulmonary resistance. This finding may be accompanied by a nonprecordial murmur (*vide infra*) (Okada and Ewy, 1983).

False-positive wide fixed splitting includes the following:

1. A normal S2 followed by the opening snap of mitral stenosis or tricuspid stenosis. The opening snap is discussed in detail later. For the present, it is sufficient to note that the interval between S2 and the opening snap is quite easily appreciated; the snap sounds exactly like a click or a snap, and the opening snap will become louder as one moves away from the base of the heart toward the mitral (or tricuspid) valve area, whereas the S2 will become softer.
2. The wide fixed split S2 must also be distinguished from a normal (single) S2 followed by a ventricular gallop (S3; *vide infra*). Again, the gallop can be heard better as one moves away from the pulmonic area down toward the responsible ventricle. Furthermore, the gallop is a low-pitched sound that can be better heard with the bell than with the diaphragm, in contrast to S2.
3. A pericardial knock of constrictive pericarditis can also imitate a wide fixed split S2.

Once you are sure that the double sound is not one of the above, but a fixed split of S2, you must compare A2 and P2 (*vide supra*) and also assign an etiology to this abnormal finding.

TABLE **17.2** *Causes of wide splitting of the second heart sound*

Delayed pulmonic closure
Delayed electrical activation of the right ventricle
Complete RBBB (proximal type)
Left ventricular paced beats
Left ventricular ectopic beats
Prolonged right ventricular ejection time
Acute massive pulmonary embolus
Pulmonary hypertension with right heart failure
Pulmonic stenosis with intact septum (moderate to severe)
Decreased impedance of the pulmonary vascular bed
Normotensive atrial septal defect
Idiopathic dilation of the pulmonary artery
Pulmonic stenosis
Atrial septal defect, postoperative (70%)
Early aortic closure
Shortened LVET
Mitral insufficiency
Ventricular septal defect

RBBB, right bundle branch block.
From Shaver JA, Salerni R, Reddy PS. Normal and abnormal heart sounds in cardiac diagnosis: Part I. Systolic sounds. *Curr Probl Cardiol.* 1985;10:1–63, with permission.

Narrow Fixed Splitting

It is apparent that wide fixed splitting of S2 is heard in many situations in which the right ventricular pressure and/or the pulmonary artery pressure are increased in the presence of a normal pulmonary vascular capacitance. However, when pulmonary hypertension occurs in the absence of volume overload, the second heart sound may have a narrow fixed split. Examples would be long-standing primary pulmonary hypertension and pulmonary hypertension due to repeated embolic episodes. Narrow fixed splitting is heard only by the experienced auscultator.

Some Speculation

If a wide fixed split of the second heart sound can be heard in atrial septal defect, partial anomalous pulmonary venous return, and ventricular septal defect (left-to-right shunt), why is it not found in pulmonic insufficiency, which can also be considered a form of volume overload of the right side of the heart? Conversely, if volume overload of the left side of the heart could delay LVET, why doesn't aortic insufficiency make the second heart sound paradoxically split?

Perhaps, in these conditions, the valvular insufficiency does not initially permit sufficient regurgitation to produce true volume overload. Ultimately, when the insufficiency is great enough to produce volume overload, an ejection murmur appears, mimicking aortic stenosis, owing to the "functional" stenosis of high flow over a normal size valve. In that case, any paradoxical splitting that occurred would be falsely attributed to the supposed aortic stenosis (*mutatis mutandis* on the right side).

An accessible, reproducible, quantitative method for comparing regurgitant volume with stroke volume might help answer these questions.

A related question is why the second heart sound splits widely in volume-overload pulmonary hypertension, and narrowly in vasculoprival pulmonary hypertension. In volume-overload hypertension, of which atrial septal defect is the archetype, the large amount of right ventricular stroke volume is being delivered to a slack pulmonary vascular tree whose compliance is so high that one can fluoroscopically observe the pulmonary tree to move in systole (the "hilar dance"). Thus, it takes a long time for the pulmonary artery pressure to exceed right ventricular pressure and so to close the pulmonic valve. However, in vasculoprival pulmonary hypertension due to the occlusion of the pulmonary vascular bed by clot, tumor,

foreign body embolus, and so forth, there is not much compliance in the pulmonary vascular tree, and the pulmonary artery pressure rises rapidly in excess of the right ventricular pressure, closing the pulmonic valve more quickly (Shaver et al., 1985). (A small elevator fills faster than a large one.)

Self-test

Construct a logic tree for findings on auscultation of the second heart sound. One correct answer is found in Fig. 17-4.

Note to Sophomores. At this point, you may be asking why so much detail is necessary? It would certainly be possible to acquire much of this inferential information in other ways. If the diagnosis can be arrived at through the use of shortcuts, why go through all this complexity?

One answer (which avoids the issue of cost) is that as a general principle of medicine, anyone who knows the mental geography of the problem is entitled to use shortcuts. However, you cannot know it is a shortcut until you know the whole neighborhood in detail. Many of the people who believe they are using shortcuts are, in fact, simply lost.

Gallops (S3 and S4)

Gallops are adventitious cardiac sounds that change the regular rhythm of "lub-dub" into a triple rhythm resembling a horse's gallop, or more correctly, canter. Also, like a horse's hoof beat, these are low-pitched sounds, resembling a man's grunt, and are best heard with the bell of the stethoscope. Because they are lower pitched than the other heart sounds, the neophyte should specifically note the pitch of the gallop so as to help his auditors be sure that he is describing a gallop and not something else.

The other dimensions that should be described for a gallop are timing, location, and change with maneuvers. Listening for the S3 with the patient in the 45-degree left-lateral decubitus position doubles the yield (Badgett et al., 1997).

Note on the Use of the Bell and Diaphragm of the Stethoscope

We speak of using the bell, *lightly* applied to the chest, for detecting low-pitched sounds, and the diaphragm for detecting high-pitched sounds. This has led some young persons to expect, erroneously, that a low-pitched sound such as a gallop would not be heard if auscultated with the diaphragm. In fact, the diaphragm is a superior auscultatory device for many sounds because the transmission is from solid to solid. The lightly applied bell detects high-pitched sounds, but *preferentially* detects low-pitched sounds. Thus, when there are many sound events across a wide-frequency spectrum, the lightly applied bell directs one's attention more to those of lower pitch, but many of these are also discernible with the diaphragm.

Timing

The rule of listening specifically to one phase of the cycle at a time is especially important for finding subtle sounds like ventricular gallops.

A useful teaching trick to help you hear (as well as identify) a ventricular diastolic gallop (an S3) is to say the word "Kentucky" with the Southern pronunciation "Ken-TUCK-uh." The syllable "ken" stands for S1, "tuck" stands for S2, and "uh" is the S3. In normally spoken English, the interval between the last two syllables will approximate the interval between S2 and S3. Once you have identified S1 and S2, silently say the word "Ken-tuck(y)" as you listen. This helps to cue your ear to the portion of early diastole (*before* atrial contraction), which contains the gallop. (Remember, however, that S1 is normally louder than S2 at the apex, the stress on the second syllable of "Kentucky" notwithstanding.) For the atrial

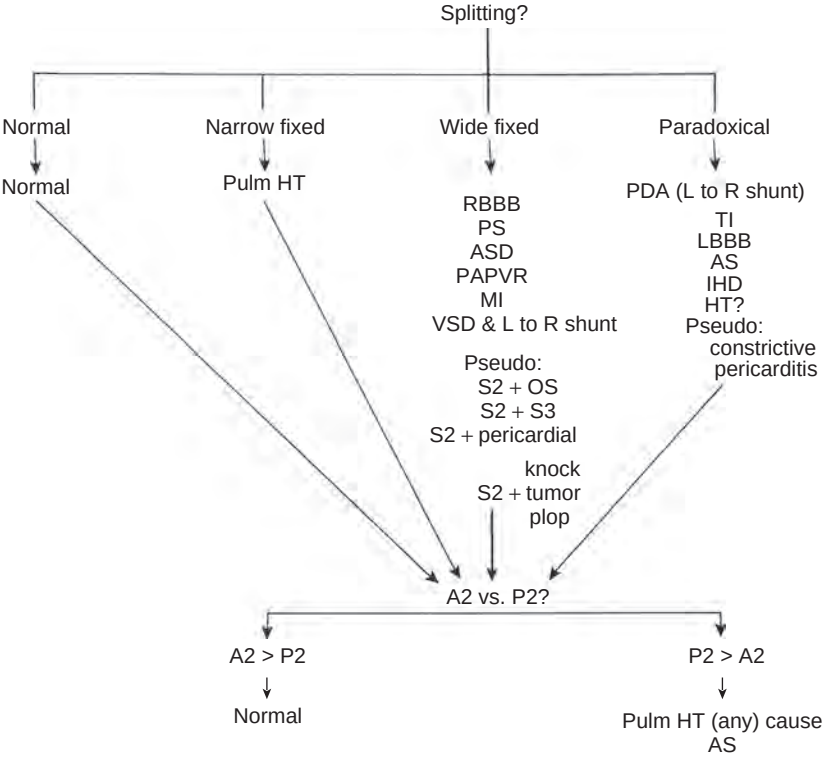


Figure 17-4 Branching logic tree for S2 splitting. Pulm HT, pulmonary hypertension; RBBB, right bundle branch block; PS, pulmonic stenosis; ASD, atrial septal defect; PAPVR, partial anomalous pulmonary venous return; MI, mitral insufficiency; VSD, ventricular septal defect; L to R, left-to-right shunt; OS, opening snap; MS, mitral stenosis; TS, tricuspid stenosis; PDA, patent ductus arteriosus; T1, tricuspid insufficiency; LBBB, left bundle branch block; AS, aortic stenosis; IHD, ischemic heart disease; HT, hypertension.

diastolic gallop (S4), think of the word "(Ten)nessee," in which the first syllable stands for the gallop. Again, the interval between the first two syllables will closely approximate the interval between S4 and S1. Unfortunately, the customary pronunciation of the word places the accent on the third syllable, whereas in auscultation at the apex, the stress should be on S1.

Remember, listen to one time interval at a time.

Gallops in Patients with a Tachycardia

Since S3 and S4 occur in different parts of diastole, it becomes obvious that one can sometimes hear what is called a *quadruple rhythm*: S4, S1, S2, and S3. However, if the heart rate speeds up, the S3 and S4 may occur at the same time, making a knocking sound called a *summation gallop* (Fig. 17-5).

If you have a patient with a very fast heart rate and a single loud gallop in diastole, slow the patient's heart rate briefly either by having the patient perform the Valsalva maneuver (see Chapter 6) or by pressing on the carotid sinus (see Chapter 18; take particular note of precautions). If the sound in diastole is a summation gallop, you will be able to hear the quadruple rhythm appear during the relative slowing of the heart. It will disappear again as the S3 and S4 fuse together into the triple rhythm summation gallop with resumption of the tachycardia.

If the induced slowing of the heart does *not* produce a quadruple rhythm, then the diastolic sound is either S3 or S4; one must determine which one it is in the customary manner.

Because one will have only a few beats to make the distinction, one must have a prepared ear. This is why the beginning medical student should gain mastery of many physical maneuvers that are infrequently used but which must be applied in less than desirable circumstances that do not permit the examiner a leisurely study. If an S4 is palpable, it is easier to identify in the presence of a tachycardia. One needs to palpate only two impulses per cardiac cycle. These will be located close together in time, at the PMI, just as diastole changes to systole. With auscultation, on the other hand, one must identify a minimum of three events per cardiac cycle and one must also arrange them mentally so as to identify them.

A Quintuple Rhythm

For theVirtuoso. Dr Joe Ojile of Missouri heard a quintuple rhythm, the description of which was greeted with open skepticism by the full professors at morning report.[7] However, he was vindicated when he produced the patient's electrocardiogram. The patient was in a Mobitz type II block with 2:1 conduction. The "extra" gallop (fifth sound) was appearing coincident with the nonconducted atrial contraction. Thus, this patient had an S1, S2, S3, and two atrial gallops, one occurring with each atrial contraction.

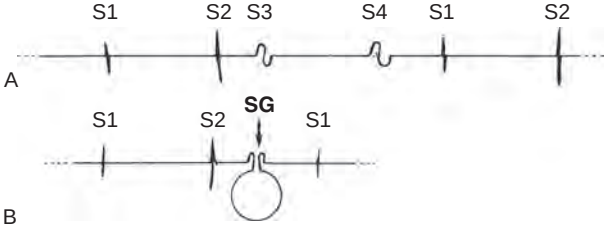


Figure 17-5 **A:** Quadruple gallop. **B:** Summation gallop (SG). With tachycardia, the RR interval shortens at the expense of diastole, the distance between S2 and S1. The portion of diastole that shortens is that between S3 and S4. You can make a topologic model of this by putting a pencil or other cylinder on the page between S3 and S4 in (A), and bending the page so that S3 and S4 occur next to each other or superimposed. (The page, viewed from the edge, would then look as shown in (B).)

Location

Both the S3 and S4 are generally best heard over the left sternal border near the xiphoid, if originating from the right ventricle. If originating from the left ventricle, they are best heard toward the apex.

Response to Maneuvers

Exercise augments both third and fourth heart sounds. A few sit-ups may be all that is required (Perloff, 1980).

An S3 arising from the right ventricle (but *not* one from the left ventricle) *may* be evoked or augmented by maneuvers that increase flow to the right side of the heart, such as (a) inspiration, (b) passive elevation of the patient's legs, or (c) pressure on the liver. If such maneuvers do *not* augment the gallop, one does not know whether it is left sided, right sided, or both.

The same maneuvers may be used to attempt to differentiate right- and left-sided S4s.

Significance

Ventricular Gallop (S3)

An S3 usually indicates that ventricular compliance is subnormal. It is the only central (cardiac) sign of congestive heart failure and is extremely important in the diagnosis of this entity. In fact, the presence of an audible S3 should ordinarily be considered diagnostic of congestive heart failure, until proved otherwise. It is the failing heart's way of saying: "I have such a low ejection fraction that as soon as the added blood from the atrium even *starts* to fill me (i.e., even before the atrial kick), it beats as a mallet against my tired, fatigued, completely noncompliant drumhead." The S3 has been found to be the best predictor of mortality at 2.5 years in patients with coronary artery disease (Zoneraich and Spodick, 1995). Patients with tricuspid insufficiency or mitral insufficiency are also stated to have ventricular diastolic gallops even without congestive heart failure. (Presumably, the drumhead need not be of decreased compliance if the mallet is big enough, which it would be when the stroke volume is composed of both the venous inflow and a large regurgitant volume from the last systole.) This gallop is not heard with mild degrees of insufficiency.

Other causes of an S3, besides congestive failure, are hypertrophic cardiomyopathy, right ventricular infarct, or constrictive pericarditis (Reddy et al., 1985). The last *may* actually be a pericardial knock.

In 90 patients undergoing elective left-sided heart catheterization, the sensitivity of a phonocardiographically recorded S3

[7] A nearly extinct practice, in which a chief of service who is a broadly based internist hears the presentation (by a doctor who has personally and thoroughly examined the patient) and offers a critical analysis of each such patient newly admitted.

for detecting left ventricular end diastolic pressure (>15 mm) and reduced left ventricular ejection fraction (<50%) was 41% and 52%, respectively, and the specificity was 92% and 87%, respectively (Marcus et al., 2005). Previous studies of an auscultated S3 have also shown low sensitivities (31% to 51%) and high specificities (90% to 97%) in detecting selected hemodynamic markers.

False Positives

The most common false positive is a "physiologic S3," sometimes heard in a perfectly healthy young person, under the age of about 20, or some may say 40 (Reddy et al., 1985). An S3 can be heard in 80% to 90% of pregnant women, and in 60%, it develops before the 20th week of pregnancy. The S3 also increases in intensity during pregnancy (O'Rourke et al., 1970).

Although a stenotic mitral valve impedes ventricular filling and so may inhibit the appearance of a pathologic S3, it does not always prevent the occurrence of a left-sided physiologic S3 (Reddy et al., 1985).

Other sounds occurring around the same time as the S3, which are thus potential false positives, include a widely split S2, an opening snap, the tumor plop, and the pericardial knock.

Atrial Gallop (S4)

A pathologic S4 is caused by the blood rushing into a ventricle with decreased compliance. The ventricular compliance has been "used up" by the blood that entered in early diastole. (It is as if the drumhead has been lightened.) The blood coming into the ventricle during atrial contraction acts as a mallet striking the noncompliant drumhead of the ventricle. (The name "atrial" refers not to the source of the noise, but to the late diastolic atrial contraction that usually propels the "mallet of blood.")

In a study of patients undergoing left heart catheterization, the sensitivity of a phonocardiographically recorded S4 for elevated left ventricular end diastolic pressure and reduced left ventricular ejection fraction was 46% and 43%, respectively, and the specificity was 80% and 72%, respectively. Patients with an isolated S4 tended to have a higher prevalence of coronary artery disease compared with those who had no diastolic heart sound or those with an S3 alone (Marcus et al., 2005).

If the S4 is heard only some of the time, irrespective of cycle, this can be a clue to the presence of complete AV dissociation. Why?

(Rarely, however, one can find an atrial gallop in situations in which there is no atrial "kick," e.g., in atrial fibrillation.)

False Positives

Inexperienced examiners often believe an S4 to be present even when it is not recordable, perhaps confusing it with a split S1 (Jordan et al., 1987). Until 1968, the differential diagnosis of an S4 was as follows: aortic stenosis and equivalents (such as IHSS) or hypertension (left-sided S4); pulmonic stenosis or pulmonary hypertension (right-sided S4); and coronary artery disease (right- or left-sided S4).

To distinguish an S4 from a split S1, Dr Phibbs advises listening for respiratory change in the two components of the sound. Respiration changes the relation of mitral and tricuspid closure and thus will affect the components of a split S1. They may move like a normal S2, or paradoxically, but they do move, whereas S4 is fixed in its relation to S1.

It is also stated that situations of high stroke volume can produce an S4. In fact, a pathologic S4 can result anytime there is decreased left ventricular compliance from heart disease. Here, one should also hear an S3, although if the heart rate is fast, S3 and S4 might appear as a summation gallop (*vide supra*). However, specific etiologies of congestive heart failure (such as hyperthyroidism and anemia) do not in themselves cause an S4 unless heart failure has supervened, contrary to the implication in some textbooks of differential diagnosis.

Atrial flutter may also cause a pathologic S4 (Reddy et al., 1985).

In the 1970s, Spodick published an elegant series of double-blind experiments showing that many apparently normal men over age 50 had an audible (but not a palpable) S4, which could be recorded (Rectra et al., 1972; Spodick, 1977; Swistak et al., 1974). This phenomenon is much more common than the innocent S3 of healthy young persons. The traditionalists did not give up without a rigorous defense, and the issue is still controversial (Abram, 1975; Fowler and Adolph, 1972; Jordan et al., 1987; Tavel, 1974; Wayne, 1974).

Personal Opinion

At the present, one may ignore an isolated, impalpable S4 in an asymptomatic man over age 50. However, if the S4 is palpable, accord it the full respect of the pre-1968 differential diagnosis given above, irrespective of the patient's age (Reddy et al., 1985). (In practice, this works almost all the time, despite the controversy.)

Murmurs

Historic Perspective

Murmurs have traditionally been among the most valuable signs of structural heart disease. For years, the ability of a physician to auscultate and interpret cardiac murmurs helped to make his reputation. For a number of reasons, this situation has changed. First, many of the people skilled in this area and its teaching have emigrated from the medical schools. Second, the prevalence of patients with murmurs has decreased because of the waning of rheumatic fever and, to a lesser extent, advances in the surgical correction of congenital heart defects. Third, the whole manner in which patients are studied has increasingly involved sophisticated imaging technology.

The current generation of Doppler echocardiograms promises to achieve the dream of accurate, noninvasive delineation of all murmur-producing cardiac structural defects, cashing in the diagnostic promissory notes previously written (in varying degrees) for the techniques of electrocardiography, ballistocardiography, vectorcardiography, phonocardiography, external pulse recordings, kymocardiography, M-mode echocardiography, and probably a few others now mercifully forgotten. If one were skilled at Doppler echocardiography and had access to the machine for every patient, this section would mostly be of use to the historian of medicine. However, financial, political, and economic constraints appear to make that eventuality increasingly remote. Moreover, as shown by autopsies of 300 randomized subjects in 1960, 1970, and 1980, remarkable advances in sonography, scintigraphy, and computed

tomography had not decreased the frequency of misdiagnoses (Goldman et al., 1983). Perhaps diagnosis is better now, but because autopsies have become so rare, we cannot know with certainty. Therefore, this section is provided on a portable diagnostic device used for detecting murmurs known as computer-assisted non-Doppler infra-ultrasound device. It is "computer assisted" by the portable computer that sits on top of your neck. It is "infra-ultrasound" because it operates at low sound frequencies (20 to 50,000 Hz), beneath the range of the ultrasound device, and the word "Doppler" is mentioned to be *à la mode*. Its inventor, Dr Laënnec, originally gave it a whimsical name ("stethoscope"), suggesting that it would enable the physician to see into the chest, and this no doubt has contributed to its unpopularity. In fact, this device is so arcane that no restrictive regulations yet govern its use.

An Epistemologic Note

In one study, five experts could agree as to whether a murmur was present or absent in only 53% of the cases (Dobrow et al., 1964). It has also been shown that, on average, internal medicine and family practice residence recognized only 20% of significant cardiac events, a proportion not significantly higher than for medical students, and that there was little improvement with a year of training (Mangione and Nieman, 1997). What do these findings mean?

The answer is that it is always possible to find someone who cannot do something (Butterworth and Reppert, 1960) and that without proper instruction and practice, one cannot learn a difficult skill. Another way of saying it, more kindly, is that there can be a problem of observer variability (Koran, 1975). However, this does not mean that the thing cannot be done. Three decades ago, before the widespread use of technologic diagnosis in cardiac disease, 80% of clinical diagnoses of congenital heart disease were "completely confirmed" at operation. In the remaining 20%, the clinical diagnosis was confirmed, but an additional unsuspected lesion was also present; however, the additional lesion made a major difference in only 3.7% of the patients (Pestana et al., 1966).

Dimensions

The dimensions that one should attempt to describe for every murmur are as follows:

1. Timing
2. Shape
3. Location
4. Radiation
5. Pitch (tone)
6. Timbre (purity of pitch)
7. Intensity
8. Effects of special maneuvers, including change in patient position

Table 17.3 illustrates how the first six dimensions, when taken together, are diagnostically specific. The effects of special maneuvers are discussed later in this chapter.

Timing

The timing of a murmur places it into one of two mutually exclusive differential diagnoses: systolic murmurs and diastolic murmurs. Additionally, although some systolic murmurs are innocent, or at least not caused by structural defects of the heart, few diastolic murmurs are without pathologic significance.

A Method

Review the methods for identifying the first heart sound. Once you have found S1, switch your attention away from the palpable PMI or the carotid upstroke and pay attention to the murmur. If it occurs after the first heart sound, then it must be in systole. If it is not in systole, it *must* be in diastole. Although this sounds simple, it takes about ten practice trials to learn it.

Shape

The shape of the murmur is what it would look like on an oscilloscope display or a phonocardiographic recording—see the schematic tracings illustrated in Figs. 17-6 and 17-7.

TABLE **17.3** *Customary (but not inviolate) dimensions of the valvular murmurs*

Lesion	Timing	Shape	Location	Radiation	Pitch	Timbre	Intensity
AS	Sys	Diamond	A	Carotids, RMClav	L to H	Coarse to pure	2–4
AI	Dias	Decrescendo	A	Sternal borders	H to M	Coarse to pure	1–2
MS	Dias	Decrescendo–crescendo	M	Almost none	L to M	Rumbling	1–4
MI	Sys	Holosystolic or diamond	M	Axilla	L to H	Pure to coarse	2–4
PS[a]	Sys	Diamond	P	Little	L to H	Coarse	2–4
PI	Dias	Same as AI	P	Left sternal border	H to M	Coarse	1–2
TS	Dias	Same as MS	T	Almost none	L to M	Rumbling	1–2
TI	Sys	Holosystolic or diamond	T	See text	L to M	Coarse to pure	1–2

[a]Most of the murmurs of most congenital heart defects that have a left-to-right shunt actually signify relative pulmonic stenosis (i.e., increased flow over a normal-sized pulmonic valve), not flow through the defect(s). Patent ductus arteriosus is the constant exception to this rule.
A, aortic; M, mitral; P, pulmonic; T, tricuspid; I, insufficiency (regurgitation); S, stenosis; RMClav, right midclavicle; H, high; M, medium; L, low; Sys, systolic; Dias, diastolic.

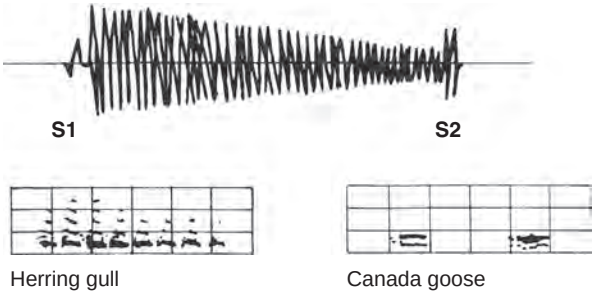


FIGURE 17-6 This holosystolic murmur used to be called a *sea gull murmur*, primarily because of the timbre. (Other causes of the sea gull timbre are given in the text.) The insets show Audubon Society recordings of the herring sea gull and the Canadian honking goose. (From Robbins CS, Bruun B, Zim HS. *A Guide to Field Identification: Birds of North America*. New York: Golden Press; 1966, with permission.) (Although traditionally shown and sounding as if it had the same amplitude throughout systole, the holosystolic murmur actually may have a slight decrease in amplitude. Note that the "holosystolic" bird calls are also slightly decrescendo.)

Systolic Murmurs

For systolic murmurs, there are two basic possibilities: the murmur may be diamond shaped or holosystolic.

Diamond-shaped Murmur. A diamond-shaped murmur may also be called *kite shaped*, or *crescendo–decrescendo*, referring to the electrocardiographic appearance (Fig. 17-7).

The term *ejection murmur* is often used, but it is confusing because certain types of regurgitant (nonejection) murmurs (such as those resulting from tricuspid or mitral valve prolapse, papillary muscle dysfunction, or the midsystolic failure of caption of the mitral valve leaflets that occurs in IHSS) can also have this shape.

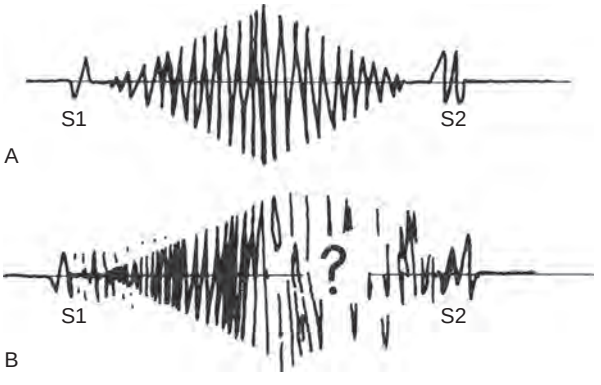


FIGURE 17-7 **A:** Diamond-shaped or kite-shaped murmur. A phonocardiographic recording is diagrammatically represented here. In recent years, the mirror-image vibrations beneath the baseline have not been shown in diagrams (e.g., Fig. 17-8, a point of confusion for the tyro, who now sees a pyramid and not a diamond). **B:** The diamond-shaped murmur as it may sound to a beginning student. For instance, preceding the ejection murmur, the slight pause after S1 may (or may not) be perceived. Furthermore, it may be initially difficult to distinguish the crescendo component. Then too, once the brain has adjusted its perceptive mechanism to the increasing amplitude, the subsequent decrescendo may be missed. (Remember that auscultation is a psychoacoustic event.) The shapes of murmurs were only appreciated after recordings became available and are best learned with devices like a phonocardiogram or heart-sound simulator that reinforce auscultation with simultaneous visual presentation.

The diamond-shaped murmur results from systolic turbulent flow at any of the four valves and is not as diagnostic as some of the other shapes (Table 17.3).

Although it is traditional to think of the murmur as turbulence due to a normal amount of blood trying to get through a small hole, it should be obvious that a similar sound will be made by an increased amount of blood trying to get through a normal-sized hole. In other words, one can have a murmur of aortic stenosis, say, or pulmonic stenosis, when the actual aortic or pulmonic valves are completely normal, but the amount of blood flow is increased. These are called *flow murmurs* or murmurs of relative stenosis. Pulmonic flow murmurs frequently occur during the last trimester of pregnancy or with congenital heart diseases that cause left-to-right shunts. Aortic flow murmurs may be heard in all conditions in which there is increased stroke volume, such as pregnancy, fever, anemia, thyrotoxicosis, and excitement with tachycardia. If there is no underlying valvular disease, the pure flow murmur is usually heard better at the pulmonic area than at the aortic area for two reasons: (a) the aortic murmur is anatomically "pointed" away from the anterior chest (superiorly and posteriorly with the aorta), while the pulmonic murmur is "pointed" to the lungs and still heard at the left upper sternal border and (b) the pulmonic valve is normally a bit smaller than the aortic valve and so will sound the flow murmur better. However, if there is so much as a little bit of aortic sclerosis, the flow murmur due to anemia, fever, and so forth will augment the basic underlying murmur and will be heard best at the aortic, not the pulmonic area.

Holosystolic Murmur. A holosystolic murmur continues throughout systole, maintaining the same apparent amplitude and timbre. It comes from the Greek prefix meaning entire or complete in the sense of being without blemish, variation, or change. If there is any *significant* change in intensity, timbre, or any other characteristic, the murmur is not holosystolic, even if it seems to fill all the time during systole (i.e., even if it is pansystolic, which simply means "across systole"). Holosystolic murmurs are caused by mitral, or sometimes tricuspid, insufficiency.

Specifically, the holosystolic murmur results from *severe* mitral (or tricuspid) insufficiency, for example, that owing to bacterial endocarditis or severe rheumatic heart diseases in which the mitral insufficiency is fixed and gaping.

Auscultators from the rheumatic fever era believed that such holosystolic murmurs started before the first heart sound (presumably during the phase of isometric contraction).

True pansystolic murmurs that reach S2 with increasing, or at least not diminished, intensity result from mitral insufficiency or a ventricular septal defect. *Pansystolic murmurs are never functional or innocent* (B.P. Phibbs, *personal communication*, 2004).

Nonholosystolic Murmur. On the other hand, the nonholosystolic murmur of aortic stenosis is preceded by a silent interval after S1. Also, in cases of mitral insufficiency due not to rheumatic valvular disease but to, say, papillary muscle dysfunction, there is no murmur during that time (early systole) when the valve leaflets are still competent. (In practice, it can be hard to prove these differences without a phonocardiograph.)

The time that a diamond-shaped murmur ends, in relation to the two components of S2, is of diagnostic value (Fig. 17-8). For example, the murmur of aortic stenosis must end before A2. A murmur

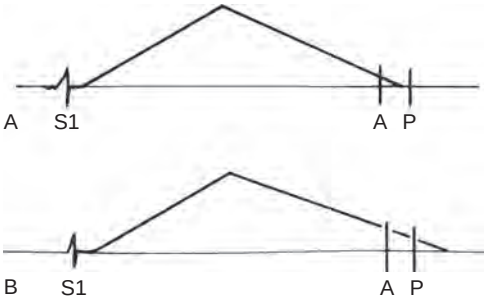


FIGURE 17-8 **A:** A diamond-shaped murmur (with mirror-image subbaseline vibrations omitted) that passes through the first (aortic) component of S2. This systolic murmur must result from mitral insufficiency, tricuspid insufficiency, or pulmonic stenosis. It cannot be explained by aortic stenosis, either organic or relative, because the murmur continues after the closure of the aortic valve. **B:** A diamond-shaped murmur that continues through both components of S2. This murmur cannot be a sign of aortic stenosis or pulmonic stenosis as both those valves have already closed while the murmur still continues. Of course, if the murmur had ended before S2, no etiology could be excluded.

extending past A2 could be pulmonic stenosis, but not aortic stenosis. However, the ability to perceive whether a murmur goes through one or both components of the second heart sound requires some experience. Although these signs were formerly taught to medical students, perhaps, in part, as a way of testing their understanding of cardiac physiology, they are now very difficult for most to learn, given the new shortened clinical examination curricula.

Some workers refer to early systolic, midsystolic, and late systolic murmurs. I am not sure why this scheme is used because almost all systolic murmurs begin sometime in early (the first half of) systole, as can be shown by recordings; all have sound extending through midsystole; and almost all have some sound in late (the last half of) systole. If these terms are being used to refer to the peak intensity of a diamond-shaped murmur, they might be useful for one phenomenon: in mitral valve prolapse, the peak moves to an earlier point in systole when the patient stands up.

Diastolic Murmurs

Almost all diastolic murmurs begin in early diastole with a decrescendo sound. These murmurs that have *only* this component are called *decrescendo murmurs*. These result from insufficiency of the aortic, or sometimes the pulmonic, valve.

Some murmurs also have a late diastolic crescendo component. These are called *decrescendo–crescendo murmurs*; 99% of them result from relative or absolute stenosis of either the tricuspid or the mitral valve, usually the latter.

These last two are low pitched. If high pitched, one should diagnose coronary artery stenosis (Dock and Zoneraich, 1967).

A Pedagogic Note. If a diastolic murmur can be assigned to one of two valves, on the basis of its shape, and four more dimensions remain to be described, there is, diagnostically speaking, a redundancy of dimensions, that is, there are more dimensions available than are needed to diagnose the individual murmurs, according to Table 17.3. A corollary for the sophomore and junior medical student is to base the diagnosis of a murmur on those few dimensions of greatest certainty. This is a good habit that should generalize into other areas.

In some clinical situations, one cannot perfectly apprehend every dimension. Thus, a mastery of all dimensions is required to pick those that permit the most confident analysis in any given case. Because of the vast amount of ordered experience that will be later required to perform such a masterful analysis in a difficult case, the student should now discipline himself to *attempt* to describe all the dimensions of each murmur, even when its etiology is already known.

As with systolic murmurs, diastolic turbulence may be produced by either a normal amount of blood flowing across a valve lumen that is decreased in size (e.g., rheumatic mitral stenosis) or by an excessive volume of blood flowing across a normal-size lumen (e.g., the relative tricuspid stenosis murmur of atrial septal defect, namely, the flow across the tricuspid valve consists not only of the normal systemic venous return but also a portion of the pulmonary venous return that has passed from left atrium to right atrium across the atrial septal defect; here, the tricuspid valve is anatomically normal but functionally small *vis-à-vis* the increased blood flow). (See also the Carey Coombs murmur, discussed later in this chapter.)

Location at Which the Murmur Is Loudest

Murmurs from specific valves are usually *best* heard in the traditional valve areas. However, some murmurs may be heard best in other areas. Always note the specific place where the murmur is loudest, even if it is not one of the usual areas.

Radiation

Aortic and pulmonic insufficiency murmurs tend to radiate from the base caudad. Aortic insufficiency murmurs may also be heard over the right clavicle (Spodick et al., 1976). Aortic stenosis murmurs tend to radiate to the neck and right clavicle. Pulmonic stenosis murmurs do not radiate very far, probably because of a lower pressure in the right ventricle. Tricuspid and mitral stenosis murmurs tend not to radiate; sometimes they can only be heard in an area about the size of a thumbprint. Tricuspid insufficiency murmurs radiate backward through the venous system, rarely being audible in unusual places like the neck veins or the varicose veins of the leg (Becker and Dick, 1962). Mitral insufficiency murmurs tend to radiate laterally, sometimes all the way to the armpit ("axilla" in Latin) or even to the subscapular region in the back. (Do not confuse the axilla with the axillary line, as many do, thereby losing a valuable discriminant between mitral insufficiency and aortic stenosis.)

1. For years, radiation of the murmur to the axilla (not the axillary line) was used as a finding specific for mitral insufficiency. Murmurs of aortic stenosis rarely (i.e., in <5% of cases) radiate there, whereas murmurs of mitral insufficiency often (but not always) do so. I have heard patients with such a radiation in whom the murmur was coming from aortic sclerosis, as proved at catheterization. This may have been a manifestation of the Gallavardin phenomenon (discussed later in this chapter). In any event, it demonstrates how tenuous the footholds of clinical diagnosis are.
2. Before the era of cardiac surgery, one could still find patients with severe rheumatic aortic stenosis in whom the murmurs sometimes radiated to the top of the head, and in one case, even

to the right elbow. But currently, radiation to the right midclavicle, with amplification, as popularized by Spodick, is the maneuver I find myself relying on most. (As far as simple radiation goes, I have heard the murmurs of both mitral insufficiency and tricuspid insufficiency radiate to the right midclavicle, but they were not amplified.)

3. According to an old piece of bedside lore, there was a form of mitral insufficiency in which only the anterior leaflet of the valve was deformed or flail due to rupture of the chordae tendineae (Guiliani, 1967). This lesion, like some ventricular septal defects, was said to produce a murmur (and even a thrill) in the left subscapular area.

Recently, the paravertebral systolic murmur was offered as a sign of postmyocardial infarction ventricular septal rupture. This is not an unexpected location, since this is just the location in which the murmur may be heard in congenital ventricular septal defect. However, it was stated that a murmur in this area was *never* secondary to mitral insufficiency (Benson and Raj, 1982). Nothing is perfect, however. One such patient went for catheterization in 1987, where it was proved beyond any doubt that the murmur radiating posteriorly was caused by mitral insufficiency and *not* by a ruptured septum.

Pitch

Pitch is the same as tone and refers to a note being played on a musical instrument. Because murmurs are not pure sound generators like the oboe, the pitch is used in cardiology to refer to the predominant register of tones, when it can be identified. As a rule, a high-pitched murmur indicates a high-pressure gradient, a narrow aperture, or both, like a strong wind passing through a cracked window, as in aortic or mitral insufficiency. Low-pitched murmurs are generally the result of a low-pressure gradient, a large orifice, or both, as in mitral stenosis or tricuspid stenosis. White noise has no pitch, and murmurs of impure timbre (*vide infra*) may not have a predominant pitch (e.g., *some* cases of aortic stenosis). If a murmur does not have a predominant pitch, do not assign one to it.

An alternate theory (Bruns, 1959) explains the pitch of murmurs in a different way.

The distinction between pitch and timbre is explained further in Chapter 16.

Timbre

Timbre refers to the "color" of a musical tone. For instance, an oboe, a clarinet, and a trumpet could each play the same note (tone), say concert C, but an experienced listener could identify each instrument by its timbre. White noise has "poor" timbre because it is harsh, coarse, and nonharmonic.

In cardiology, the timbre refers to the purity of the murmur (or the lack thereof). The semeiophysiology of pure timbre involves the repeated vibration of something at a constant frequency with dominant harmonics. Thus, murmurs due simply to hemic turbulence do not usually have good timbre. However, if there is something that can be vibrated, such as a valve, various degrees of musicality can result.

Murmurs described as "honks," "whoops," and "cooing like a dove" are purer than those that are "harsh." The former may be described as "musical." A prolapsed mitral valve, which most resembles a single reed instrument, produces one of the most "musical" murmurs (i.e., one with pure ["good"] timbre). Aortic stenosis *can* produce the least musical murmur, a "harsh" murmur with impure timbre. The timbre of the murmurs of tricuspid and mitral stenosis is somewhat like that of a male voice speaking the word "rub." Thus, some cases of mitral stenosis have a relatively pure timbre even though they are low-pitched rumbles.

The murmur of ruptured chordae tendineae resembles someone humming through a kazoo (pure tone but impure timbre). (However, as with all diseases, milder forms are discovered with time, and some cases of ruptured chordae tendineae are nonemergent ambulatory ones presenting with only one chordae tendineae ruptured and a flail mitral leaflet that sounds just like everyday mitral regurgitation.) Most cases of aortic insufficiency have a poor timbre, sounding almost like the white noise of breath sounds, without a predominant pitch. However, some cases of aortic insufficiency will produce a diastolic cooing sea gull murmur (Fig. 17-6), which has a very good timbre.

Such musical diastolic murmurs were once thought to be of ominous prognosis because of the association with syphilitic aortic leaflet retroversion. With the decreasing prevalence of cardiovascular syphilis, the same murmur is now heard more frequently with aortic insufficiency of the usual causes and no longer has such a bad prognosis (Sheikh et al., 1984).

Some cases of aortic stenosis or rheumatic mitral insufficiency may also have a cooing dove or sea gull murmur.

Descriptive Phrases: A Caution

Many phrases, particularly the birdcalls,[8] used to describe murmurs actually describe shape, pitch, and timbre *simultaneously*. For instance, the "sea gull murmur," which resembles the musical call of a herring gull (*Larus argentatus*), has high tones, relatively pure timbre, and a pansystolic shape. Persons who do not understand this may misname a murmur based on only one or two dimensions, thus confusing others to whom these dramatic descriptive phrases have very complete and specific meanings. Worse, the former may never learn to identify the other dimensions.

Self-experiment

Ask five classmates to commit to writing their working definitions of "blowing murmur," "musical murmur," and "sea gull murmur." How much consistency is there?

If mitral regurgitation is caused by prolapse, it may sound more like a Canadian goose (*Branta canadensis*), as may tricuspid prolapse. Aortic insufficiency, when birdlike, tends to sound somewhat like the great black-backed gull (*Larus marinus*), but higher pitched, like the common tern (*Sterna hirundo*). Aortic stenosis, when birdlike, sounds more like the laughing gull (*Larus atricilla*).

[8] If one examines the records of actual birdcalls, such as those available from the Audubon Society, one discovers that the different species of sea gulls, doves, and so on each have remarkably different calls, so the avian analogy could be quite confusing, as well as incorrect, if the species is not given with the genus.

Intensity

By tradition, murmurs are graded on a scale of 1 to 6, which was initially a research tool in a study of systolic murmurs (Freeman and Levine, 1933; Levine and Harvey, 1949).

Grade 1: The murmur is heard, but not at first
Grade 2: The faintest murmur that can be heard immediately upon placing the stethoscope on the precordium
Grade 3: A murmur intermediate between grades 2 and 4. It is louder than a grade 2 but is not associated with a thrill
Grade 4: A murmur that is associated with a thrill but is not as loud as a grade 5
Grade 5: A murmur that can be heard through the stethoscope if just the rim is held against the chest (i.e., with the chest piece tilted)
Grade 6: A murmur that can be heard with the stethoscope head held in front of the patient's chest without actually touching it

The reason for grading intensity is that Freeman and Levine found that innocent systolic murmurs were almost never grade 3 or more. This was a useful piece of information in an era in which there was no cardiac catheterization and no surgical treatment, but a great deal of worry about innocent (or not-so-innocent) systolic murmurs.

Although most young clinicians use intensity as one of only two or three dimensions in their descriptions of murmurs, it is placed at the end of this list because it is of less use in diagnosis than the other dimensions. Whereas innocent systolic murmurs do indeed tend to be of grade 2 or less, many (noninnocent) structural abnormalities may also produce only a grade 2 murmur, including diastolic murmurs (which Freeman and Levine did not study) and right-sided murmurs.

Innocent Murmurs

Innocent murmurs are discussed last for clarity because they *lack* the characteristics and associated findings of the various pathologic murmurs that have just been described (Table 17.3). They are quite common. In unreferred young persons, the prevalence of systolic murmurs ranges from 5% to 52%, whereas echocardiography is normal in 86% to 100%. Echocardiography is normal in 90% to 94% of pregnant women referred for testing because of systolic murmurs (Etchells et al., 1997).

Innocent murmurs are only grade 1 to 2, and more than 99% are systolic (Table 17.4). Functional diastolic murmurs have been described during pregnancy. One study found that 9 of 50 normal primigravidas had a low-frequency diastolic murmur heard best at the left sternal border, maximal in middiastole, attributed to increased flow across the tricuspid valve. Others have reported a high-frequency early diastolic murmur during pregnancy that is maximal over the pulmonic area and disappears after delivery; it is attributed to functional dilatation of the pulmonary artery during gestation (O'Rourke et al., 1970).

One common form is the vibratory murmur originally described by Still. This is a short, buzzing murmur that probably originates from periodic vibrations of the pulmonic leaflets at their attachments. It is best heard at sites overlying the body of the right ventricle. A pulmonic midsystolic murmur occurring in young persons represents an exaggeration of normal ejection vibrations within the pulmonary trunk. These are the kinds heard in high-output states such as pregnancy, anemia, fever, and hyperthyroidism. (Reasons why such murmurs are "pulmonic," not "aortic," are found earlier in this chapter.) Innocent supraclavicular systolic murmurs originate in the brachiocephalic arteries and are always louder above the clavicles. Perloff considers aortic sclerosis to be one of the innocent murmurs (as it is when it is *mild*). The mammary souffle[9] is discussed in Chapter 15.

TABLE **17.4** *Innocent systolic murmurs*

Murmur	Origin
Vibratory systolic murmur	Pulmonic leaflets (Still murmur)
Pulmonic systolic murmur	Pulmonary trunk
Peripheral pulmonic murmur	Pulmonary branches
Supraclavicular or brachiocephalic	Origins of brachiocephalic murmur vessels
Systolic mammary souffle	Breast vessels during pregnancy
Aortic sclerosis	Fibrous thickening of aortic cusps

From Perloff JK. Cardiac auscultation. *Dis Mon.* 1980;26:1–47, with permission.

Innocent murmurs are to be distinguished from functional murmurs. In the former everything is normal, whereas with the latter, flow is increased, say, because of pregnancy or anemia.

Up to 96% of pregnant women develop a functional murmur, usually ejection in quality and less than grade 3 in intensity. In addition to the murmurs attributed to increased flow across the pulmonic or aortic valves, there is frequently a supraclavicular arterial murmur that is heard maximally in the supraclavicular fossa and over the carotids but may be transmitted to the upper precordium (O'Rourke et al., 1970).

Imitating the Sound of Murmurs

For the Attending. Mitral or tricuspid insufficiency murmurs of the holosystolic type may best be imitated by whistling until the mouth is dry and the musicality is thus lost. Another method is to listen through the stethoscope while holding the diaphragm in your hand and quickly drawing a finger from the ulnar to the thenar side of the dorsum of the hand. (This is not completely satisfactory because the heart sounds are omitted.)

The murmur of aortic stenosis has been likened to the sound of a steam engine chugging up a hill. For prairie dwellers and young persons who have never heard a steam engine on an upgrade, the grunt made by older persons of Mediterranean stock as they settle

[9] Here, souffle is pronounced "sue-full," not "sue-flay." The former means whisper or breath. The latter is an egg dish, inflated and inspired.

their arthritic joints into a chair is a passable substitute. (This sound is sometimes called a *kretschmer*.)

Another way to imitate the murmur of aortic or pulmonic stenosis is to place the bell in your hand and draw a circle on the back of your hand. Start the circle by striking the back of your hand with your finger to generate an "S1." The sound will crescendo, and if you end the circle at the starting point and do not raise your finger, you will have to slow down, producing the decrescendo part of the murmur. There will not be an "S2" with this technique, but in some cases of very severe aortic stenosis, the aortic valve opens so little that closure produces a very feeble aortic component of the second sound. In these cases, there are places on the chest where S2 is not audible, so this is a pretty good imitation.

A good approximation of the sound of aortic and pulmonic insufficiency can be generated by listening through the stethoscope with the diaphragm on your anterior neck while whispering the word "par," "peer," or "tare." The consonant, snapping from the lips, represents S2. The rest of the word is the decrescendo murmur. It should be of the same pitch and timbre as your breath sounds. (That is why the patient must always hold his breath during the search for this murmur.) Another way to imitate the murmur of aortic insufficiency is to place your stethoscope in the palm of your hand as before, but this time, start the sound by striking the back of your hand (for S2) and draw your finger down your arm toward your elbow. To decrease the volume of the murmur, you might even start at the wrist and stroke about halfway down toward the elbow.

Both of these techniques produce a murmur of too great a volume. Once you have "heard" this murmur, change your technique so as to produce a grade 2 murmur.

(These murmurs are discussed in greater detail earlier in this chapter.)

Continuous versus To-and-Fro Murmurs

Murmurs occupying both systole and diastole are of two types, diagrammed in Fig. 17-9. The first sounds are like one (continuous) murmur in pitch and timbre. The most common example if the patient is sitting or standing is the cervical venous hum (Table 17.5 and Chapter 19).

The other murmur occupying systole and diastole, the to-and-fro murmur, actually sounds like two different murmurs, as it is. It can be caused by any combination of lesions capable of producing a systolic and a diastolic murmur. The to-and-fro murmur is

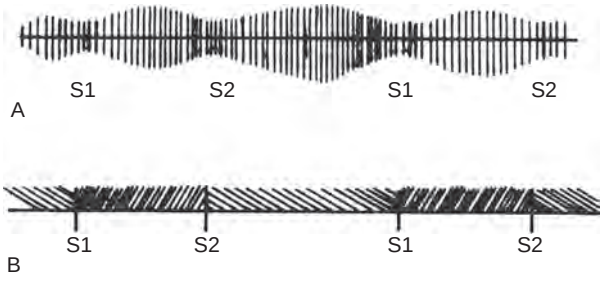


FIGURE **17-9** **A:** Continuous murmur. **B:** To-and-fro murmur.

TABLE **17.5** *Differential diagnosis of continuous thoracic murmurs (in order of decreasing frequency)*

Diagnosis	Key findings
Cervical venous hum	Disappears on compression of the jugular vein
Hepatic venous hum (see Chapter 20)	Often disappears with epigastric pressure (Rusconi et al., 1985)
Mammary souffle (see Chapter 15)	Disappears upon pressing hard with stethoscope
Patent ductus arteriosus (Gibson murmur)[a]	Loudest at second left intercostal space
Coronary arteriovenous fistula	Loudest at lower sternal borders
98% of cases, ruptured aneurysm of sinus of Valsalva (Pan-Chih et al., 1981)	Loudest at upper right sternal border, sudden onset
Bronchial collaterals	Associated signs of congenital heart disease
High-grade coarctation	Brachial/pedal arterial pressure gradient
Anomalous left coronary artery arising from pulmonary artery	
Anomalous pulmonary artery arising from the aorta	
Pulmonary artery branch stenosis	Heard outside the area of cardiac dullness
Pulmonary arteriovenous fistula	Heard outside the area of cardiac dullness
Atrial septal defect with mitral stenosis or atresia	Altered by the Valsalva maneuver
88% of aortic–atrial fistulas (Hurley et al., 1986)	
Superior caval syndrome due to syphilitic aneurysmal dilation of aortic root and mediastinitis	Systolic accentuation; second and third right interspaces (Lian, 1937)

[a]This was called the "machinery murmur" because it had the continuous harsh sound of the early 20th century machine shops whose devices were individually belt-driven by a single master rotor kept in continuous motion. Neither the machine shop nor the murmur is much extant. Those patients who do not have surgical care develop pulmonary diastolic hypertension, and the murmur becomes purely systolic.

From Holmes JC, Fowler NO, Helmsworth JA. Coronary arteriovenous fistula and aortic sinus aneurysm rupture. *Arch Intern Med.* 1966;118:43–54, with permission.

not always continuous. Usually, it has a late diastolic silence (if the diastolic component is owing to aortic or pulmonic insufficiency), a middiastolic silence (if the diastolic component is owing to mitral or tricuspid stenosis), or an early or late systolic silence. There are also great pitch and timbre differences in the systolic and diastolic components. However, when first stumbled on, the psychoacoustic event most closely resembles what is shown in Fig 17-9. It is only after careful timing and auscultation that the silent spots and pitch and timbre differences are detected. Then, the auscultator knows not to do the differential diagnosis of Table 17.5, but rather the separate differential of (at least) one diastolic and one systolic murmur.

Venous Hums as Continuous Murmurs and Systolic Murmurs

The cervical continuous venous hum was first auscultated in 1819 by Laënnec. The diagnosis of cervical venous hums is given in Chapter 19.

Mammary souffles, hyperthyroid eyeball bruits, and other potentially continuous murmurs of increased flow may all be considered examples of venous hums. However, the venous hums most likely to cause difficulty during the auscultation of the heart are those coming from the liver.

The latter was first reported by Pegot in 1833, and the autopsy was published by Cruveilhier in 1835. The patient had superficial abdominal varices, which were auscultated, as the source of the venous hum. The venous hum of cirrhosis in the absence of visible abdominal wall varices was explicated in 1868 by Trousseau (Bloom, 1950). (The diagnosis of hepatic venous hums is given in Chapter 20.) Hepatic venous hums are snares for the unwary cardiologist. It is not well appreciated that these venous hums may also be heard in alcoholic hepatitis, hepatoma, and a wide variety of other liver disease (Clain et al., 1966), nor is it appreciated that these venous hums may radiate from the liver to the precordial area (McFadzean and Gray, 1953) or even be heard *better* precordially than over the liver (Bloom, 1950). Finally, although usually continuous, these murmurs may be only systolic (Clain et al., 1966), in which case they are termed "arterial murmurs," which does nothing to lessen the confusion of the auscultator who is not aware of their true meaning.

Pericardial Friction Rubs

Timbre

A pericardial friction rub sounds like creaky leather, or in some cases, a rhonchus beating in time with the heart.

Location

Pericardial rubs are often not heard over all parts of the precordial area. A rub may be audible only in an area about the size of a nickel (2 cm in diameter) and sometimes is heard only at the border of cardiac dullness. About 84% of rubs are best heard along the left sternal border (Spodick, 1975).

Phases

A three-component (triphasic) pericardial friction rub is pathognomonic for pericarditis (generally acute or subacute; rubs are absent in chronic, constrictive pericarditis). "Three-component" means that there are three sounds for each cardiac contraction, or what a musician would call a triplet. Note that the middle note of the triplet is quite soft in many cases, so that one must listen carefully and repeatedly in a perfectly quiet room to detect this diagnostically perfect finding.

In a study of 100 patients with acute pericardial friction rubs, about 55% of the rubs were triphasic. One patient with pericarditis was even found to have a quadriphasic rub (Spodick, 1975).

If the rub has two components (biphasic), one can be reasonably certain that there is pericarditis. In the same study (Spodick, 1975), about 33% of the rubs were biphasic; all of these had a systolic component plus either an early or late diastolic component. About 9% of the rubs would have been triphasic if the heart rate had been slower because these patients had a summation diastolic component similar to a summation gallop. Such biphasic "to-and-fro" rubs may also result from the absence of atrial systole. However, atrial or other arrhythmias are rare in acute pericarditis, unless accompanied by underlying myocardial or valvular disease (Spodick, 1983).

If the rub has only one component, it is still indicative of pericarditis; however, such a rub is likely to be misidentified as a murmur. In that situation, the optimum way to resolve the problem is not to order an echocardiogram but to reexamine the patient until one "catches" the rub demonstrating its other components.

Rubs, like gallops, tend to be evanescent in borderline situations.

About 10% of the patients with pericardial rubs have pericardial effusion, thus demonstrating that a rub does not rule out an effusion (Spodick, 1975). A discussion of other findings in pericardial effusion is found in the "Synthesis" section later in this chapter.

The Pleuropericardial Rub

It is often hard to tell what is meant by this phrase. What we will mean is that the clinician has heard a pericardial rub synchronous with the cardiac cycle and accentuated according to respiratory phase. Actually, this is the case with most pericardial rubs (Harvey, 1961; Spodick, 1975). We will not use this word to refer to the concept that both the pleural surface and its facing parietal pericardial surface are inflamed because this has not always been directly proved in any case and may not be relevant in most. Even in patients with known pulmonary disease, a rub does not necessarily originate from the pleura. Patients with viral pneumonia could also have a viral pericarditis (Levine and Harvey, 1949). However, in one patient who had a pulmonary infarction, the pleural friction rub heard near the heart border did appear at one point to have a superimposed cardiac cycle accentuation (a pericardiopleural rub?). How can one tell the difference? The traditional advice has been to distinguish between pleural and pericardial etiologies by having the patient hold his breath in a given phase of respiration. However, it is quite possible that a rub of pericardial origin might not be heard during one phase of respiration (*vide supra*), and if one were to pick that phase, one might erroneously conclude that the rub was pleural. Accordingly, if one wishes to try this maneuver, one should have the patient hold his breath both in full inspiration and later in full expiration.

Other Systolic Adventitious Heart Sounds

Systolic Clicks (Prolapse Clicks versus Ejection Clicks)

In general, early to midsystolic clicks result from (a) mitral or tricuspid valve prolapse (these are not ejection clicks); (b) high-pressure

valve opening; (c) nonstenotic congenital bicuspid aortic valves and the entire spectrum of mild-to-severe stenosis of the aortic valve (Shaver et al., 1985); (d) dilation of the great vessels (poststenotic or aneurysmal); (e) systemic hypertension, in the setting of a tortuous sclerotic aortic root (a tight, noncompliant arterial tree and forceful left ventricular ejection) (Shaver et al., 1985); or (f) a prosthetic valve.

False Positives

As mentioned earlier, an ESC must be distinguished from a doubled S1 and from an S4–S1 complex.

An ejection click in the presence of aortic stenosis implies that the stenosis is valvular, and not supravalvular or subvalvular (IHSS). Similarly, pulmonic ejection clicks occur in pulmonic valvular stenosis, but not in subvalvular stenosis. They may also occur in other conditions of pulmonic valve dilation such as hyperthyroidism and idiopathic dilation of the pulmonary artery, of which the latter 80% will also have a pulmonic insufficiency murmur (Ramsey et al., 1967).

Both aortic and pulmonic ejection clicks occur very early in systole, right after the first heart sound. They may be distinguished from each other by the fact that they are best heard in their respective valvular areas and do not radiate well (Shaver et al., 1985).

A more important distinction is that between both of these ejection clicks and the "nonejection" prolapse clicks of mitral valve and tricuspid valve prolapse. These latter clicks are best heard over their respective valve areas and usually occur later in systole. If the patient stands up, the prolapse click may then occur earlier in systole. Such positional movement does not occur with the ejection clicks.

Any ESC almost guarantees that an accompanying murmur is not innocent.

Means–Lerman Scratch of Hyperthyroidism

A peculiar systolic scratchy sound, halfway between a murmur and a friction rub, was first reported in 6% of male and 12% of female patients with hyperthyroidism. All the patients with this sound were in the subgroup that had no other cardiac symptoms or signs (Lerman and Means, 1932).

> We have noted an unusual noise in the moderate and severe cases of hyperthyroidism. It consists of a rough grating systolic murmur which has some of the characteristics of a friction rub, heard best over the sternum in the region of the second interspace. It is superficial, heard best at the end of full expiration and obscured by full inspiration. Its intensity subsides as the metabolism and heart rate drop under the influence of [treatment] and usually disappears after [thyroidectomy]. On several occasions the diagnosis of pericarditis was suspected by members of the hospital staff on the basis of this friction rub. We are not certain as to its causation.... It may have some relationship to the dilated pulmonary conus often seen in the roentgen ray pictures in this condition. (Lerman and Means, 1932)

More than 30 years later, this sound was shown to result from a combination of early pulmonic ejection sounds superimposed on a short scratchy ejection murmur, which resulted from the increased velocity of ejection in this disorder (Leonard et al., 1963).

A Means–Lerman scratch can also be heard in patients with fever and anemia, but with a normal thyroid status.

Other Diastolic Adventitious Heart Sounds

Timing the Early Diastolic Sounds

Before Bell Telephone Company was split up, it was easy to teach the unit of 0.04 second because that was the interval between picking up the receiver (releasing the depressed receiver rest) and hearing the dial tone. Now, this interval must be learned phonocardiographically or from some heart-sound simulators. For those who wish to take the trouble, the early diastolic intervals are given in Table 17.6.

Early Diastolic Tumor Plops

Atrial myxomas often grow on pedunculated stalks that permit considerable mobility. They not only produce changing or positional diastolic (and sometimes systolic) murmurs, but in early diastole they may also plop into the ventricle. The early diastolic sound so produced is called a "tumor plop."

Early Diastolic Pericardial Knock

Constrictive pericarditis produces an early diastolic "pericardial knock" at approximately the same time as S3. (The incoming blood strikes a "pretightened" drumhead.) It may be accentuated by having the patient squat (Nicholson et al., 1980).

Early Diastolic Opening Snap

The opening snap of mitral or tricuspid stenosis, discussed later in this chapter, needs to be distinguished from a widely split S2. Opening sounds or clicks can also be heard with (a) prosthetic mitral valves, (b) mitral regurgitation, (c) ventricular septal defect, (d) thyrotoxicosis, (e) tricuspid atresia with a large atrial septal defect, and (f) second or third degree AV block (Reddy et al., 1985).

Early Diastolic Click

An early diastolic click may be heard in 5% to 15% of patients with mitral valve prolapse (Cheng, 1987), owing to reverse ballooning of the prolapsed mitral leaflet.

TABLE **17.6** *Early diastolic intervals*

S2 (normal expiration)	<0.03 s
S2 (inspiration, young persons)[a]	0.04–0.05 s
S2 (widely split)	0.06–0.08 s
S2 opening snap (Reddy et al., 1985)	0.03–0.15 s
S2 pericardial knock	0.10–0.12 s
S2–S3	0.14–0.16 s
S2–S3 in normal children (Reddy et al., 1985)	0.12–0.20 s

[a]This value decreases with age, such that a single S2 during both phases of respiration may be perceived in normal subjects older than 40 years.
From Reddy PS, Salemi R, Shaver JA. Normal and abnormal heart sounds in cardiac diagnosis: Part II. Diastolic sounds. *Curr Probl Cardiol.* 1985;10:8–55, with permission.

Late Diastolic Pacemaker Sound

Rarely, a right ventricular pacemaker produces a late diastolic (presystolic) sound called the "pacemaker sound," which occurs immediately after the onset of the pacing stimulus. Its high-pitched and clicking characteristics differentiate it from an S4. The sound is believed to be caused by contraction of chest wall muscles, which are stimulated by the electrical impulse from the pacemaker. This does not necessarily imply perforation of the right ventricle (Perloff, 1980).

Other Adventitious Heart Sounds that May Be Systolic and/or Diastolic

Prosthetic Valve Sounds

The auscultatory findings depend on the type of valve that was implanted. The acoustic characteristics of various prosthetic devices have been reviewed (Smith et al., 1981). Ball valves produce opening and closing clicks. Disk valves produce closing clicks. Tissue (porcine) valves usually produce closing sounds in both aortic and mitral positions. These sounds are crisp and high pitched, but much less prominent than those of mechanical devices. A pericardial xenograft or a porcine mitral valve may also have an opening sound (Smith et al., 1981; Szkopiec et al., 1983).

Prosthetic valves typically produce a systolic murmur. Disk or porcine mitral valves also may have a diastolic rumble (Smith et al., 1981). However, aortic diastolic murmurs, ball valve diastolic murmurs, and new diastolic murmurs mean prosthetic valve dysfunction until proved otherwise (Reeves, 1982).

Mill Wheel Sound of Air Embolism

There is one very unusual type of almost continuous sound that does not deserve to be called a *murmur* because it is more like a splashing sound, resembling that of a water wheel at a grist mill. In fact, it is called a *mill wheel* or a *mill pond murmur*. The splashing is caused by intracardiac blood, and the diagnosis is air embolism. You should immediately roll the patient onto his left side to decrease the chance of embolism to the brain.

Mediastinal Crunch

As alluded to in Chapter 16, there is little to add to the story of spontaneous mediastinal emphysema and its auscultatory hallmark, the mediastinal crunch, as it was originally told (Hamman, 1939):

> Case 1. On February 12th, 1933, Dr W. Cabell Moore invited me to come to Washington to see a physician, fifty-one years of age, who had symptoms strongly suggesting the occurrence of coronary occlusion. Theretofore he had always been a robust, healthy man busily engaged in carrying on an exacting practice. On the morning of February 8, while shaving, he was suddenly seized with intense pain under the sternum radiating to the left shoulder....
>
> I examined the heart and the lungs with the greatest care and could detect nothing that was to the least degree abnormal. When I expressed chagrin at my lack of skill, the patient laughingly said that he could easily bring on the sound which excited so much interest. He turned on his left side and after shifting about for a few moments said, "There it is, I hear it now." I put my stethoscope over the apex of the heart and with each impulse there occurred the most extraordinary crunching, bubbling sound....
>
> Case 2.... On the previous afternoon while sitting quietly in a chair, he suddenly had a feeling of pressure under the sternum as though a lump were forming. Soon swelling actually appeared above the clavicles and he had severe pain on breathing deeply, on swallowing, and on turning the head.... There was subcutaneous crepitation over the front of the neck, which extended backward to the trapezius muscle on both sides and downward over the clavicles to about the second rib on the left and to the nipple on the right. When I put my stethoscope over the heart, there was the same systolic crunching sound which had so perplexed me when I heard it over the heart of the Washington physician....
>
> Case 3.... A young physician, twenty-five years of age, an interne at the Emergency Hospital, Washington, was admitted as a patient, February 21, 1934, complaining of pain in the left side of the chest and peculiar crackling noises in the region of the heart. He had had a slight cold for two or three weeks with a little cough and mucoid expectoration. On the day before entering the hospital, he had had rather sharp pain over the heart increased by deep breathing and by coughing. A few hours later as he was leaning on his desk, he suddenly heard a curious crackling noise, apparently coming from that part of the chest where the pain was located. He listened with interest and observed that the crackling sound came synchronously with the heartbeat. When he sat up straight the sound immediately vanished....
>
> When the patient turned upon his left side a curious moist crepitant, or crackling, noise was heard with each contraction of the heart, so loud that through the stethoscope it was almost painful to the ear. It could be heard by the bare ear held a foot from the chest wall. When the patient turned upon his back these peculiar sounds at once disappeared....
>
> Case 4.... As he got out of the car he was taken suddenly with a very severe pain under the lower end of the sternum and a sensation of pressure or choking....
>
> ...While the patient was lying on his back, just inside the apex beat, could be heard a queer crackling, bubbling sound with each systole. When he turned upon his side, the sound disappeared....
>
> Case 5.... At about 5:45 o'clock on the afternoon of January 11, while walking from work, he was seized suddenly with a severe, sharp, stabbing pain over the lower part of the left chest....
>
> ...Over the left axillary area were found the physical signs of a partial pneumothorax. The area of cardiac dullness was much diminished in extent.
>
> ...Over the lower portion of the sternum and to the left of it, in the fourth and fifth interspaces, there were curious crunching, clicking sounds varying in intensity with each systole....
>
> Case 6.... At about three o'clock the following morning the mother was awakened by hearing the boy cry out with pain. When she went to him he complained of severe pain over the right lower chest....
>
> ...The evening before, subcutaneous emphysema had been noted above both clavicles. On this morning, it was more pronounced and extended up the neck on both sides to the ears. Over the whole sternum, and louder still over the heart, numerous crackling, popping sounds could be heard greatly accentuated with each contraction of the heart....
>
> Case 7. Dr L., 25 years of age, resident obstetrician at Sinai Hospital, is a short, stockily built man of vigorous appearance.... On September 6, 1937, while eating lunch, he began to notice pain in the lower left axillary area....
>
> ...When he shifted to the left side loud bubbling, crackling sounds occurred synchronously with the slow beating of the heart, louder with systole than with diastole....

> In order to mark clearly the essential clinical features of spontaneous interstitial emphysema of the lungs and mediastinum I shall summarize the important symptoms.
>
> Interstitial emphysema of the lung may occur without the least effort, when the patient is quietly standing, sitting, or lying down....
>
> In many instances a peculiar and distinctive sound is heard over the heart synchronous with its contractions. Usually the sound is heard only during systole but at times it may be heard also during diastole. The area of cardiac dullness is diminished or completely obliterated, the dullness being replaced by a hyperresonant percussion note....When air appears in the subcutaneous tissues of the neck, the diagnosis is at once assured.

A more recent case was reported by Dr David Rosen of Minnesota. A patient presented to the emergency room with a stab wound to the chest and a mediastinal crunch, which the surgeon did not believe to be significant. When the wound was probed with a gloved finger, the patient developed third-degree heart block and required an emergency pacemaker.

One case was reported in which a patient presented himself to the emergency room only on the insistence of his girlfriend, who was bothered by the sloshing sound in his chest (Collins, 1994).

(Also see Chapter 16.)

Special Maneuvers

Maneuvers That Affect the Intensity of Murmurs

Listening to the patient during various maneuvers and changes in position may be necessary to hear certain murmurs and may also help in the differential diagnosis (Cochran, 1978; Nellen et al., 1967; Rothman and Goldberger, 1983), particularly when the maneuvers are used as excluders.

Position

1. Before you can legitimately say that a patient does not have a murmur of aortic insufficiency, you must listen to him in a sitting position, leaning forward, with his breath held, preferably in expiration.
2. Listen for the murmur of mitral stenosis with the patient in the left-lateral decubitus position. The best time to listen is immediately after the patient has rolled into that position. First, place the stethoscope bell just a bit inside the PMI or the percussed apex, and then have the patient roll into position. I adopted this idea from Dr Sam Levine, who believed that much of the augmentation of the murmur in the left-lateral decubitus position was the result of the exercise (and increased flow) or moving into that posture. (Other methods of bringing out the mitral stenosis murmur—having the patient inhale amyl nitrite or hop up and down 25 times so as to cause a tachycardia—work by a similar mechanism [Levine, 1945]). Dr Thomas Dorman teaches that if you place your arm behind the patient's back and allow him to rest on your arm while you listen in this position, muscle noise will be decreased.
3. Standing decreases ventricular filling and so increases only two murmurs, that of IHSS and that of 74% of cases of mitral valve prolapse (Popp and Winkle, 1976; Rothman and Goldberger, 1983). (In some instances, it may just make the prolapse murmur longer, so that it seems louder.) Standing generally decreases all other valvular murmurs, including aortic stenosis, pulmonic stenosis, valvular mitral insufficiency, or tricuspid insufficiency (Cochran., 1978; Rothman and Goldberger, 1983). However, it has been observed that standing may increase innocent murmurs and the murmur of aortic sclerosis, and perhaps even aortic stenosis, at least transiently, as the body attempts to respond to the sudden demand for increased output (J.E. Atwood, *personal communication*, 1998).
4. Squatting increases ventricular filling and increases afterload.[10] It decreases the murmur in 89% of IHSS but usually does not decrease the murmurs of valvular aortic stenosis, valvular mitral insufficiency, or pulmonic stenosis. Squatting can increase the murmur of mitral insufficiency. It increases the pulmonary flow murmur and the ventricular defect murmur of a ventricular septal defect, forcing more of the blood through the defect into the right heart (Lembo et al., 1986; Rothman and Goldberger, 1983).

Because of the effects on afterload, squatting also increases the murmur of aortic insufficiency. (In fact, squatting is the second best way to elicit the murmur of aortic insufficiency [Vogelpoel et al., 1969]). The best way is transient arterial occlusion (see later in this chapter).

Except for the case of ventricular septal defect, all the statements in this section have published exceptions (Lembo et al., 1986).

Inspiration

Inspiration may increase the murmur of the right-sided lesions: pulmonic stenosis, pulmonic insufficiency, tricuspid stenosis, and especially tricuspid insufficiency. It has been suggested that left-sided murmurs can be identified by their tendency to *decrease* in intensity with inspiration; this sign is valid, however, only if the heart tones remain of constant intensity because otherwise the decrease may simply reflect the increased distance between the heart and the stethoscope caused by the inflated lungs.

In one study, an increase in the murmur with inspiration had a 100% sensitivity for a right-sided origin. The specificity was 88%, and the PV of a positive test was 67% (Lembo et al., 1988).

Cycle Length

As a general rule, the cycle length affects ventricular filling and will therefore specifically alter those murmurs produced by an obstruction to the normal outflow. Thus, the murmurs of aortic stenosis (and probably of pulmonic stenosis) increase after a longer diastole, whereas the murmurs of mitral insufficiency (and probably of tricuspid insufficiency) do not (Rothman and Goldberger, 1983). It is believed that the murmur of IHSS also changes with

[10] Afterload is aortic valve resistance plus systemic vascular resistance. If there is no aortic valve lesion, then afterload is the same as the peripheral vascular resistance, which is now called systemic vascular resistance by some. If there is an aortic valve lesion, then its resistance is fixed and the change in afterload will be due to the change in systemic vascular resistance.

cycle length, but this can be extremely confusing at the bedside and should be used only within the strict limitations explained later in this chapter.

Amyl Nitrite

A Method

Crack open an ampule and have the patient inhale deeply as you listen. The amyl nitrite will induce a tachycardia. Make your judgment about the murmur when you hear the increase in rate. The biggest change occurs first, so you should try to make a quick decision. To be able to make a good decision on the basis of small evanescent auditory samples requires a great deal of experience. This method was probably more useful in earlier days when phonocardiograms were widely available.

To diminish the odor in the room, you may wish to dispose of the ampule in a closed container, preferably one filled with potassium hydroxide. Because the amyl nitrite causes a vascular headache in a large percentage of people, you need to inquire about that before leaving your patient.

Mechanism

The inhalation of amyl nitrite causes a decrease in afterload or at least the portion due to systemic vascular resistance. It can be thought of as a "reverse handgrip" (*vide infra*), as it generally causes opposite effects.

Effect on Systolic Murmurs

Amyl nitrite intensified the murmur of 84% of cases of aortic stenosis and 89% of cases of IHSS, but only 0%, 6%, 13%, and less than 22% of series of cases of mitral insufficiency. However, because of the increased flow and increased venous return, the murmur of 84% to 89% of cases of tricuspid insufficiency also increased (Rothman and Goldberger, 1983). The murmur usually decreases in small ventricular septal defects (Lembo et al., 1986; Rothman and Goldberger, 1983).

The murmur of isolated valvular pulmonic stenosis increased in 88% of cases. However, if the stenosis was subvalvular, the murmur paradoxically decreased if the ventricular hypertrophy was sufficiently severe. Also, if the pulmonic stenosis was part of the tetralogy of Fallot, the murmur definitely decreased (Rothman and Goldberger, 1983).

A decrease in a systolic murmur with amyl nitrite was 80% sensitive for a diagnosis of mitral regurgitation or ventricular septal defect, with a specificity of 90% and a positive PV of 84% (Lembo et al., 1988).

Effect on Diastolic Murmurs

In 60% to 82% of cases of mitral stenosis and tricuspid stenosis, the murmurs increased. However, 86% of the Flint murmurs (see later in this chapter) decreased (Rothman and Goldberger, 1983). Amyl nitrite decreased 80% to 93% of the murmurs of aortic insufficiency, but none of the murmurs of pulmonic insufficiency (Lembo et al., 1986; Rothman and Goldberger, 1983).

Handgrip

This isometric exercise increases systemic vascular resistance (or afterload). Thus, it may be thought of as a "nonpharmacologic" phenylephrine infusion.

A Method

Place the patient in the position in which the murmur is best heard. Auscultate the murmur at rest and then during 1 minute of sustained maximal handgrip. Although the studies of this maneuver used a handgrip dynamometer (McCraw et al., 1972), it is said that a typical response can be elicited by squeezing a rolled-up face cloth or merely by clenching the fist forcefully (Fowler, 1980).

The expected increase in systemic vascular resistance does not always occur, and the murmur does not always change in the expected direction. In a few patients with aortic insufficiency, mitral insufficiency, mitral stenosis, and ventricular septal defect, the measured change was in an opposite direction from that predicted (Lembo et al., 1986), so the result of the handgrip should be used only as a weak excluder. For example, an increase in a systolic murmur almost always excludes aortic stenosis or IHSS (Rothman and Goldberger, 1983). A decrease in the intensity of a systolic murmur almost excludes ventricular septal defect and mitral insufficiency. A decrease in the intensity of a diastolic murmur with handgrip would tend to exclude the diagnoses of aortic insufficiency and mitral stenosis.

An increase in the murmur with handgrip was 68% sensitive for mitral insufficiency or ventricular septal defect, with a specificity of 92% and a positive PV of 84% (Lembo et al., 1988). A decrease in the murmur with handgrip was 85% sensitive for IHSS, with a specificity of 75% and a positive PV of 46% (Lembo et al., 1988).

Transient Arterial Occlusion

Just as Duroziez increased the diastolic murmur of aortic insufficiency heard at the femoral artery by increasing the downstream resistance, so may all murmurs of left-sided insufficiency (also including mitral insufficiency and ventricular septal defect) be augmented by transiently occluding the brachial arteries with blood pressure cuffs inflated 20 to 40 mm Hg above systolic pressure for 20 seconds (Lembo et al., 1986).

An increase in a left-sided insufficiency murmur with transient arterial occlusion was 75% sensitive for aortic insufficiency and 80% sensitive for mitral insufficiency or ventricular septal defect, with positive PVs of 100% (Lembo et al., 1986, 1988). Although the method is not perfectly sensitive (sometimes there is no change), none of these murmurs decreased with the maneuver, so a decrease in intensity would be a useful excluder.

Valsalva Maneuver

For the Attending. Phonocardiologists discovered that the response of murmurs to various phases of the Valsalva maneuvver (see Chapter 6) could be diagnostically useful. However, many of these experts did not indicate which phase of the Valsalva maneuver they were referring to in their charts. Because the different phases may have different effects on the same murmur, the resulting literature is confused and confusing. Worse, some of the phases of the Valsalva maneuver are passed through in just a few heartbeats. It seems optimistic at best to suggest that a neophyte can identify the phase from changes in the RR interval without an external recording device such as an electrocardiograph machine. Furthermore, it is not clear how the physician can be expected to learn to identify a change in

intensity that lasts for but a few beats, now that the phonocardiograph is in a pecuniary, insalubrious, and ill-deserved eclipse.

For all these reasons, I personally do not teach the Valsalva maneuver. However, the fortunate few whose "bedside" equipment includes intra-arterial recording devices can consult a comprehensive review (Nishimura and Tajik, 1986).

The Scratch Test

The frontal cardiac silhouette has been outlined by what is now known as the scratch test. The original description (Burton-Opitz, 1925) cannot be improved on:

> I should like to call attention to a simple method of auscultatory stroking which has given excellent results as proved by means of the fluoroscope and Roentgen photographs. While I have used this procedure principally in mapping out the heart, it may be applied with equal accuracy to other organs, such as the liver and kidneys.
>
> The bell of the stethophone is placed over the sternum at the second interspace. By means of a blunt colored pencil, short vertical strokes are then made from without inward, beginning about three inches to the right of the sternum. As the pencil is moved inward, a line will eventually be reached when the sound suddenly increases in its intensity. This point is marked with the pencil. The stethophone is then lowered about an inch each time and this process repeated, until the entire right border of the heart has been charted in this manner.
>
> The stethophone is now raised to its former level at the second intercostal space, while stroking movements are made with the pencil beginning at a point three inches to the left of the sternum. The point at which a sudden increase in the intensity of the sound is noted is again marked. The stethophone is then moved downward and this process repeated. At about the fourth rib, the stethophone is shifted towards the left so that it comes to lie over the main mass of the ventricles. Sweeping oblique strokes are then made, beginning about four inches above the bell of the stethophone. This process is repeated in successive radial lines until the entire left border of the heart has been outlined.
>
> The accuracy of this method may be tested in the following manner. A paste made of mucilage and barium sulphate is applied with a camel's hair brush in such a way that the different colored marks are joined with one another in the form of a line about three millimeters in width. The patient is then fluoroscoped. If the outlining has been correctly done, the barium line cannot be differentiated from the dark borders of the heart. Furthermore, if the patient moves the tip of his index finger along the barium line, it can readily be noted whether this line corresponds with the fluoroscopic findings. Additional proof of the accuracy of this method has been obtained by the taking of numerous x-ray plates showing the barium line superimposed upon the boundary of the heart shadow.

Synthesis

The rest of my account will be concerned with the hidden membranes of the heart—a piece of craftsmanship deserving description above all others. There are membranes in the cavities, and fibres as well, spread out like cobwebs through the chambers of the heart and surrounding the orifices on all sides and emplanting filaments into the solid wall of the heart. In my opinion these serve as the guy-ropes and stays of the heart and its vessels, and as foundation of the arteries. Now there is a pair of these arteries, and on the entrance of each, three membranes have been contrived, with their edges rounded to the approximate extent of a semicircle. When they come together it is wonderful to see how precisely they close off the entrance to the arteries.

—*The Hippocratic Writings*, Edited by G.E.R. Lloyd and translated by Iain M. Lonie

This section might equally well be called *cogitation*, after Osler's famous fifth maneuver (i.e., inspection, palpation, percussion, auscultation, and cogitation).

Aortic Insufficiency[11]

Detecting the Murmur

Listening for the Murmur

To hear an aortic insufficiency murmur, you must specifically listen for it with the patient properly positioned. It is worth reemphasizing that the breath must be held; the timbre of the aortic insufficiency murmur is similar to that of the normal breath sounds over the precordium.

The murmur may be augmented by squatting or transient arterial occlusion (*vide supra*).

Aortic insufficiency murmurs are always heard best in the left parasternal region. If you hear an aortic insufficiency murmur to the right of the sternum, it means there is an aortic aneurysm (B.P. Phibbs, *personal communication*, 2004).

Sensitivity

The sensitivity of auscultation for the diagnosis of aortic insufficiency is 73% (Grayburn et al., 1986; Meyers et al., 1982). The sensitivity of the diastolic murmur for some examiners has also been determined for each degree of aortic insufficiency (Cohn et al., 1967): it was 32% for trivial lesions, 69% for mild lesions, 65% for moderate lesions, and 95% (Cohn et al., 1967) to 100% (Bland and Wheeler, 1957; Segal et al., 1956) for severe lesions. In grade 1 lesions accompanied by aortic stenosis, the sensitivity of the murmur was only 40%, and in grade 1 lesions accompanied by mitral stenosis, the sensitivity was 25% (Linhart, 1971).

To give a perspective on the relative worth of technology, the sensitivity of auscultation of the murmur for the diagnosis of aortic insufficiency is still superior to the sensitivity of magnetic resonance imaging for the diagnosis of multiple sclerosis (Stewart et al., 1987).

Does Length of the Murmur Predict the Severity of Insufficiency?

One would predict that the degree of aortic insufficiency could be estimated from the (inverse) length of the murmur on the basis of the Wiggers diagram of simultaneous pressure curves versus

[11] In reference to a valve, insufficiency and regurgitation are synonymous.

time (i.e., with a small degree of aortic insufficiency, it would take more time for the pressure in the left ventricle to rise up to the aortic pressure than if there were a huge leak). With the latter, the pressure would presumably equilibrate rather quickly and so retrograde flow would diminish quickly, producing a short-lived murmur. Unfortunately, I have not been able to find a single paper in which this hypothesis has been tested by actually measuring the duration of the murmur. Given the present unwarranted underuse of phonocardiography, it is unlikely that this situation will improve in the near future. Other than the Hill sign (*vide infra*), I know of no reliable predictor of the degree of the insufficiency, not even the pulse pressure.

Peripheral Signs

In addition to the help in distinguishing the aortic insufficiency murmur from that of pulmonic insufficiency, some peripheral signs of aortic insufficiency can be helpful when the patient is unable to sit up and hold his breath for auscultation or when ventilatory sounds or the noises of a busy hospital unit confound serious precordial auscultation.

The Duroziez Sign

A Method

In a quiet room, place the diaphragm of the stethoscope over the femoral artery. *Gradually* compress the artery. At first, a systolic murmur will be heard. (This occurs in everyone.) Continue *slowly* to increase the pressure on the artery. In aortic insufficiency, a very early diastolic decrescendo murmur will also be heard at a critical point: a pressure equivalent to the diastolic plus three fourths of the pulse pressure (Luisada, 1943). If the pressure of the stethoscope is too great or too little, the murmur will not be heard.

In patients with unilateral atherosclerosis, it may be possible to elicit a Duroziez sign over one femoral artery but not the (obstructed) other.

Sensitivity

The sensitivity of a properly performed Duroziez sign is 58% to 100% (Sapira, 1981).

False Negatives

Causes of false negatives include very mild aortic insufficiency, superimposed mitral valvular disease (due to decreased left ventricular stroke volume—mitral stenosis decreasing left ventricular filling and mitral insufficiency decreasing left ventricular forward ejection), superimposed aortic stenosis, and any other situation that interferes with pulse-wave propagation from the heart to the femoral artery (such as coarctation of the aorta or occlusive iliofemoral arterial disease).

False Positives

Double murmurs may also be heard in high-output states such as thyrotoxicosis, patent ductus arteriosus, fever, severe anemia, and an AV fistula in the leg being examined. All these high-output double murmurs (except patent ductus arteriosus) are forward-flow murmurs, as opposed to the double murmur of aortic insufficiency, whose diastolic component is a reversed-flow murmur resulting from the blood actually moving backward toward the incompetent valve. The forward-flow diastolic components may be distinguished from the reversed-flow diastolic components of aortic insufficiency (and patent ductus arteriosus) by a technique originally described in the 19th century by Potain as a modification of the method of Duroziez, and later (in English) by Blumgart and Ernstene (1933), as follows.

While listening to the diastolic murmur, tilt the stethoscope so that the cephalad rim is compressing the femoral artery (Fig. 17-10A). With a forward-flow diastolic murmur, the sound-generating turbulence will now be under the stethoscope and will be well heard. Now tilt the stethoscope so that the caudad edge is compressing the femoral artery (Fig. 17-10B). The forward-flow, sound-generating turbulence will now be occurring downstream from the stethoscope, and the diastolic component will become softer or disappear (Blumgart and Ernstene, 1933).

With a reversed-flow diastolic component, the opposite occurs. Pressing in with the cephalad rim of the stethoscope will cause the reversed-flow murmurs to be softer, whereas pressing with the caudad rim accentuates the sound (Fig. 17-10C and D).

Using this modification, the positive PV of the Duroziez murmur approaches 100%, the degree of imprecision reflecting exactly the

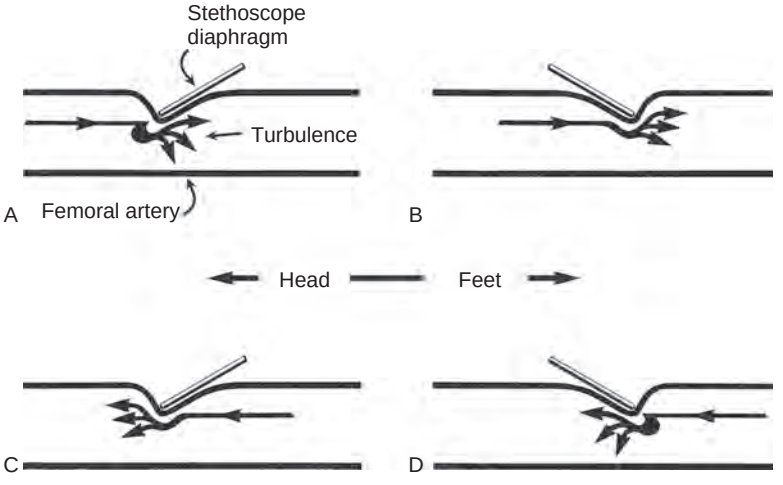


Figure 17-10 The Duroziez sign. Distinguishing a forward flow **(A,B)** from a reverse flow **(C,D)** diastolic component (see text).

prevalence of patent ductus arteriosus in one's clinical population (Sapira, 1981), although patent ductus is easily diagnosed on separate clinical grounds (see footnote to Table 17.5).

Another use of the Duroziez sign is simply to make the diagnosis of aortic insufficiency in those cases in which the precordial diastolic murmur is not heard. At first, this seems paradoxical because both murmurs result from the diastolic reversal of flow in the aorta. Consider, however, that the Duroziez murmur is produced right under your stethoscope, by your stethoscope, whereas the aortic whiff must be auscultated remote from its origin under a blanket of bone and muscle. Furthermore, adventitious lung sounds and ventilators interfere less with femoral than with precordial auscultation.

The Hill Sign

The Hill sign, although useful for estimating severity of the regurgitation (or other high stroke volume conditions), is so little used that you could become an instant expert, just as anyone who takes up croquet in the US can immediately be ranked.

A Method

With the patient in the horizontal position, compare the brachial artery systolic pressure with the popliteal (or dorsalis pedal) artery systolic pressure, indirectly determined by palpation or auscultation. Normally, the two indirectly determined pressures will be the same, or the apparent systolic pressure in the lower extremity will be up to 20 mm Hg higher (see Chapter 6).

Although high stroke volume due to any cause (such as hyperthyroidism, AV fistula, pregnancy, beriberi, or strenuous muscular exertion) may cause the indirect systolic pressure to be more than 20 mm Hg *higher in the lower* extremity than in the upper extremity, aortic insufficiency is the most important cause.

Unfortunately, mild ("one plus") aortic insufficiency generates brachial–pedal gradients of less than 20 mm Hg. However, above 20 mm Hg, a positive Hill sign is highly significant, and the degree of the systolic pressure gradient is directly proportional to the degree of aortic insufficiency determined at cardiac catheterization (Sapira, 1981) if you have already independently determined that aortic regurgitation is the cause of the increased stroke volume.

A Caveat. Because the dependent variable is the systolic blood pressure, the test cannot be performed in patients whose systolic blood pressure varies from beat to beat, for example, those with atrial fibrillation and highly irregular RR intervals (see Chapter 6).

Semeiophysiology

The pathophysiology of the Hill sign is still uncertain. Some experts believe that in conditions of high stroke volume, a rebound wave returns from the periphery. The summation of the rebound wave and the aortic pressure pulse wave is believed to produce the Hill sign. This would certainly explain why the Hill sign is lost with direct intra-arterial recordings and why it is seen in so many conditions with high stroke volume. It would also explain why the degree of the artifact predicts the severity of the valve lesion, since greater insufficiency should result in a larger stroke volume. It would even explain how the sign can be lost in aortic stenosis (which decreases stroke volume) and mitral stenosis (through interfering with ventricular filling, thus reducing the stroke volume), should either of these conditions appear in association with the aortic insufficiency (Sapira, 1981). However, it does not explain why the summation wave should be present in the popliteal or dorsalis pedis vessels and not in the brachial vessels.

So, another idea is that with large stroke volume there is also a pressure wave at right angles to the forward wave, like dinner moving through a boa constrictor. The two waves sum only in the lower extremities because the upper extremity vessels exit the aorta at right angles.

Remember, this is an artifact of indirect blood pressure measurement. This sign is not useful when making direct measurements from the aorta and femoral artery (Sapira, 1981).

False Positives

Severe, selective atherosclerosis in the upper extremity (i.e., Takayasu disease) can cause a false-positive Hill sign.

False Negatives

The Hill sign (like the Duroziez sign) requires a high stroke volume and no interference to propagation of the pulse wave. Thus, mitral stenosis, aortic valvular stenosis, and aortic internal obstruction will each make the sign disappear.

There is an interesting situation in which the Duroziez murmur is maintained but the Hill sign disappears: the supervention of low-output cardiac failure, replacing the previous high-output cardiac failure. In this case, there is no longer sufficient stroke volume to produce the Hill sign. This is an extremely important clue that tells you the time for surgical intervention has passed, a conclusion that can soon be ratified by expert opinion, supported by a quire of expensive studies.

Another instance in which the Hill sign may be lost before the Duroziez sign is atherosclerosis or other obstructive disease occurring between the femoral artery (where the Duroziez sign is sought) and the popliteal (or dorsalis pedis) where the measurement is made for the Hill sign.

Other Occasionally Useful Peripheral Signs of Aortic Insufficiency

Carotid Shudder

In a patient with a basal diastolic murmur in whom it is not possible to perform the tests for the Duroziez sign or the Hill sign because of atrial fibrillation or iliofemoral thrombosis, evidence for aortic insufficiency may be adduced by finding the carotid shudder, discussed in Chapter 18.

The De Musset Sign

The De Musset[12] head-bobbing sign, best seen in patients who are sitting or standing quietly, consists of a bobbing or brief forward

[12] De Musset (who was not a physician) was considered one of the greatest French poets of the 19th century. He is now remembered only as a lover of George Sand and as the discoverer of this sign, a reflection of his own luetic aortic insufficiency (Sapira, 1981). As Osler once remarked about Jean Astruc, "It is strange how the memory of a man may float to posterity on what he would have himself regarded as the most trifling of all his works" (Osler, 1987).

shaking of the head in time with the heartbeat. It is the only sign that will spontaneously attract one's attention, but it is not very sensitive and also has false positives (Sapira, 1981).

The Corrigan Pulse

The Corrigan pulse (see Chapter 18), also known as the Watson water hammer pulse, was first described by de Vieussens in 1715 (Stone, 1986). This sign, rarely felt today, is a palpable manifestation of wide pulse pressure. It is of imperfect sensitivity and specificity for the diagnosis of aortic insufficiency and can even be felt in patent ductus arteriosus.

Pulse Pressure

Despite the conventional wisdom, the pulse pressure is of little use in assessing the degree of aortic insufficiency present in any given patient (Bloomfield and Sinclair-Smith, 1973), even when the pulse pressure is constant from time to time. Nor does it matter whether the gold standard for the degree of aortic insufficiency is that observed at surgery of the mitral valve (Cohn et al., 1967) or the angiogram taken preoperatively (Cohn et al., 1967; Frank et al., 1965).

Nor does the pulse pressure correlate with prognosis, despite repeated statements to the contrary. When used as part of a triad, abnormal blood pressures could predict a group with lower mean survival, but there was no statistical evidence that blood pressure alone so correlated (Spagnuolo et al., 1971). In another study, the blood pressure measurements failed to predict death, including that occurring perioperatively (Smith et al., 1976). In a third, there was no significant prediction of myocardial death versus an excellent surgical outcome, although the latter group tended to have the lower diastolic and wider pulse pressure (Samuels et al., 1979). A fourth study similarly found no PV for the pulse pressure regarding perioperative mortality (Louagie et al., 1984). All these papers were found in a review claiming just the opposite of what they showed.

The diastolic blood pressure was also of little use (Cohn et al., 1967). Admittedly, the combination of a diastolic pressure of at least 70 mm Hg and a pulse pressure of less than 40 mm Hg excluded the presence of moderate or severe aortic insufficiency, but the contrary was not true (Cohn et al., 1967).

The Rosenbach Sign

In one series of aortic insufficiency patients (Tice, 1911), 14% had hepatic pulsation. The Rosenbach sign is rarely seen today because patients are usually operated on before their lesion becomes severe enough to produce it.

The Gerhard Sign

The Gerhard sign is pulsation of the spleen, which can be detected only if the spleen is enlarged for another reason.

The Becker Sign

Visible pulsations of the retinal arterioles are called the *Becker sign*.

The Müller Sign

A pulsating uvula is called the *Müller sign* (see Chapter 13).

"Pistol Shot" Sounds

A "pistol shot" sound is heard at the femoral artery in 45% of cases of very severe aortic insufficiency (Tice, 1911). It is nondiagnostic, also being found in other high stroke volume states, such as anemia and hyperthyroidism (Levine and Harvey, 1949), and in aortic dissection (see Chapter 18).

Traube Sounds

The Traube femoral double sound eludes most examiners because they do not perform the requisite maneuver. As repeatedly pointed out (Laubry et al., 1931; Traube, 1872), if one simply applies the stethoscope lightly to the femoral artery, one will almost never hear the double tone. However, if one compresses the femoral artery distal to the stethoscope head with just the correct amount of pressure, one will be able to find the double tone, likened by Traube to heart tones.

The sensitivity of the double tone was 24% in a series of 124 patients with aortic insufficiency (Tice, 1911). A few of these patients had triple tones.

An Historic Interlude

The Franco-Prussian War may have had an influence on the diagnosis of aortic insufficiency in the US. In the second half of the 19th century, the German medical tradition seems to have had greater influence on medical education and practice in the US than the French, possibly because the US was less well positioned to import medical traditions earlier when the French tradition was ascendant.

In the first paper describing the double tones (Fraentzel, 1867), it is stated by Fraentzel that Traube had recently made this discovery. It is noteworthy that Traube was the *Geheim Rath* and Fraentzel was his assistant.

(A *Geheim Rath*, literally a "secret advisor," was an extra-academic appointment, not limited to the medical or academic world. Persons of eminence could be appointed by and to the king or baron. Because of their political power, many of these *Geheim Rath* personages found that they could attract to themselves ambitious, more energetic young workers, especially in academia. In time, a *Geheim Rath* came to mean an academic entrepreneur whose time had passed, but who continued to put his name on the original work of his assistants, who were free to leave if they objected. They did not, of course, because they also hoped to become a *Geheim Rath* one day. Predictably, the Queen of Medicine soon left Germany. We are indeed fortunate to live in a time and place in which older academicians do not exploit their fiduciary relationship with their younger colleagues.)

Traube obviously discovered his sign by pressing on the femoral artery distally, while following Duroziez's instructions on how to produce the sign bearing the latter's name. How else can one explain what Traube was doing (i.e., listening to a patient with aortic insufficiency at the femoral artery, with his finger compressing the artery distally)?

In the second paper (Traube, 1872), published right after the Franco-Prussian war, Traube himself noted a very few cases in which the double tone could be heard without the Duroziez maneuver ("*so erscheint auch in dem Ausnahmefall der Doppelton ohne daß die Arterie*

comprimiert zu werden braucht," Traube, 1872). This second Traube sign, performed without distal arterial compression (which further distanced him psychologically from the Frenchman Duroziez) was very rare and was found only in cases of severe aortic insufficiency with massive left ventricular dilation. Traube himself heard it only five times (Traube, 1872) in 5 years. This second Traube sign (the one attempted in the US) will usually be absent in aortic insufficiency.

In contrast, the Duroziez sign is encountered frequently, yet has been unpopular in this country. Most American texts mention it only to denigrate its usefulness, even though most such authors do not seem to have read Duroziez's papers and do not give correct instructions on how to produce the sign (Sapira, 1981). Furthermore, most of the criticisms leveled against the Duroziez sign were answered in his original papers, which oddly enough have yet to be translated into English in their entirety.

Has the vigorous promotion of a rare sign of aortic insufficiency in preference to a more useful Gallic maneuver been nothing more than the residual influence of the Franco-Prussian War and a *Geheim Rath*?

Useless "Signs"

Two signs of aortic insufficiency that were once presented in textbooks of physical diagnosis are actually useless.

The Quincke Sign

The Quincke pulse can be seen by exerting, on the edge of the nail, a pressure that is greater than the diastolic but less than the systolic. Quincke described it thus:

> …a clear (whitish) zone in the nails can be produced by an even pressure…in the area between the whitish, clear, zone and the red, injected, zone of the capillary system of the nail bed, in the majority of persons examined there is with each heart beat a forward and backward movement of the margin between the red (zone) and the clear (white) zone, and one can convince himself that the increase of the redness follows a moment later than the apex beat and is still clearly systolic and rather rapid; while the backward movement of the edge of the redness seems to take place more slowly (Quincke, 1868; see also Major, 1945).

This is a normal phenomenon present in everyone, not a pathognomonic sign of aortic insufficiency or anything else (Sapira, 1981). The first person to notice that the Quincke pulse was present in normal persons was Quincke himself!

The Mayne Sign

The Mayne sign is another useless "sign" erroneously thought to indicate to aortic insufficiency (Abbas and Sapira, 1987). This is a decrease in the indirect diastolic blood pressure of 15 mm Hg when the arm is held above the head, compared with the baseline diastolic blood pressure taken with the arm at the level of the heart (Mayne, 1953). This sign occurs in 65% of normal persons (Abbas and Sapira, 1987).

Etiologies

1. It is a rule of thumb (Harvey et al., 1963) that rheumatic lesions of the aortic valve and syphilitic *valvular* disease (i.e., luetic[13] involvement of the leaflets without valve-ring dilation) produce a diastolic decrescendo murmur that radiates best to the third or fourth *left* (not right) intercostal space, whereas aortic insufficiency murmurs due to bacterial endocarditis or aortic root (nonvalvular) causes usually radiate more loudly to the *right* sternal border. So, if the murmur radiates best to the right, be alert for endocarditis or other entities associated with aortic root disease (such as aortic aneurysm, dilation of the aortic root, aortic dissection, aneurysm of the sinus of Valsalva, Marfan syndrome, traumatic valve deformity, osteogenesis imperfecta, rheumatoid spondylitis, Behçet syndrome, and syphilis) (Harvey et al., 1963). If it is loudest on the left, you should search for coexistent disease of another valve, a common finding in rheumatic disease.
2. The murmur of aortic insufficiency can result from hypertension with diastolic pressures above 130 mm Hg. If the patient is given a ganglionic blocker (such as hexamethonium) that causes orthostatic hypotension, the murmur goes away when the patient is tilted upright (Leonard and Allensworth, 1963). When the patient is placed recumbent, the blood pressure rises, and the murmur will return. Some older hypertensives may also have aortic insufficiency murmurs at diastolic pressures as low as 90 to 100 mm Hg. Perhaps there is also some underlying structural abnormality, but the murmur disappears when the diastolic pressure is lowered to 80 to 90 mm Hg (Leonard and Allensworth, 1963).
3. Aortic valve fenestration (Friedman and Hathaway, 1958), which is usually not hemodynamically significant, may produce an audible aortic insufficiency murmur. This lesion is hard to find by echocardiography but is more frequent than expected at careful autopsy.
4. For years, students were taught about an early diastolic decrescendo blow heard in chronic renal failure and putatively signifying aortic insufficiency, yet there were no associated peripheral signs of aortic insufficiency, and the murmur quickly disappeared with treatment. Attempts to find the aortic insufficiency at catheterization were so unsuccessful that some concluded this sound was actually a pericardial rub. We now know that this sound is the result of volume-overload pulmonic insufficiency (Perez et al., 1985).

Epistemology

The signs of aortic insufficiency in the present section were derived predominantly from studies of chronic aortic insufficiency. The semeiophysiology of acute aortic insufficiency remains a *terra incognita* despite the statements (unreferenced) of many experts that the semeiophysiology is different, based on the "fact" that the ventricle has not had time to enlarge and so produce a large stroke volume. From personal experience, I know that some high stroke volume signs *are* sometimes evident in acute

[13] "Syphilis" was the name of the afflicted hero in Frascatorius' 1530 poem. *Lues* is Latin for misfortune and became a euphemistic synonym for syphilis during considerate bedside presentations prior to penicillin. We retain and practice it today for similar reasons.

aortic insufficiency, although I do not know how often because of insufficient experience. I also know that some of the expert statements about the semeiophysiology of acute aortic insufficiency are written by the same people who believe that the Quincke sign indicates aortic insufficiency and do not realize that it is a normal finding. How much of modern clinical scholarship is based on perceptive clinical experience and how much of it is simply sequential copying thus remain unknown. This teaches us that medical history repeats itself, and medical professors repeat each other.

Aortic Stenosis

Clinical Findings

If you have been reading this text sequentially, you already know almost everything that you need to know about valvular aortic stenosis. First, you know that aortic valvular stenosis is manifested clinically by the presence of the characteristic murmur in a patient with left ventricular hypertrophy. Second, you are aware of the utility of the right midclavicular amplification of this murmur (Spodick et al., 1976). Third, severe cases produce paradoxical splitting of S2. (The carotid shudder and the *parvus-et-tardus* carotid upstroke are discussed in Chapter 18.)

Remember, aortic stenosis produces a murmur that can be heard in any of the anterior areas covered by General Patton sash (as portrayed in the motion picture starring George C. Scott). This red sash passed, anteriorly, from the right midclavicular area down over the aortic valve area, further down to the apex, and to the fifth and the sixth intercostal spaces in the anterior and midaxillary lines, but not into the axilla.

An increase in the murmur with handgrip almost always excludes aortic stenosis. The murmur tends to increase in intensity after a long diastole or amyl nitrite.

An Additional Bedside Method for Evaluating the Degree of Stenosis

Estimate the interval between the peak PMI (felt with the right hand) and the peak of the carotid artery upstroke (felt with the left hand). Ordinarily, these are very close together, but they become separated in time, in proportion to the severity of the stenosis (Chun and Dunn, 1982). Although the effective use of this estimate requires a lot of experience with aortic stenosis patients, it also requires an appreciation of the normal; something that one can begin accruing immediately.

A narrow pulse pressure, once cited as a characteristic feature of aortic stenosis, no longer seems to be of diagnostic value in the present population of patients with aortic stenosis (Lombard and Selzer, 1987), although in individual cases it could be helpful *if present*.

An extensive literature review showed that the most useful findings for diagnosing aortic stenosis were as follows: slow rate of rise of the carotid pulse (positive likelihood ratio [PLR] 2.8 to 130), mid to late peak intensity of the murmur (PLR 8.0 to 101), and decreased intensity of S2 (PLR 3.1 to 50). The most helpful finding for excluding aortic stenosis is the absence of murmur radiation to the right carotid (negative likelihood ratio[14] 0.05 to 0.10) (Etchells et al., 1997).

Etiologies

The etiology of aortic stenosis depends on the location of one's practice. In places where rheumatic fever (which is still a major health problem in developing countries) still exists, most cases of aortic stenosis in younger persons (under age 50) are rheumatic. Where rheumatic fever becomes rare and the population lives long enough to get the degenerative diseases, half the cases in patients under 50 will be due to bicuspid valves and half the cases in patients over 50 will be due to degenerative calcification of tricuspid valves (Passik et al., 1987).

Differential Diagnosis: When Is Aortic Stenosis Not Aortic Stenosis?

One problem for the auscultator is to recognize when the murmur of aortic stenosis is not from valvular aortic stenosis. Can you name a condition in which that is the case? Write your answer down. After reading the next section, you should be able to list several.

Relative Aortic Stenosis

Relative aortic stenosis from aortic insufficiency is not absolute aortic stenosis. (If you gave a different answer, it might still be right—read on.) In aortic insufficiency, the left ventricle is filled not only from the left atrium but also by the regurgitant blood passing back through the defective aortic valve (both events occurring in diastole). Thus, on the next systole, there is an increased stroke volume across the aortic valve, which (although leaky) is normal in area. The increased flow over the normal valve produces the same turbulence as a normal stroke volume flowing over a decreased valve area. This relative flow murmur may be misinterpreted as an absolute valvular murmur. (The words we use to communicate clinical findings, like language in general, are quite treacherous, unforgiving, persistent in their obfuscation, and concealing of their misdirection, as Count Korzybski pointed out in *General Semantics*.)

Aortic Sclerosis

Aortic sclerosis is a roughening of the valve that may not initially cause obstruction or a systolic gradient, but that can produce a murmur identical to that of aortic stenosis. Mild aortic sclerosis does not in and of itself produce a delay in LVET, and so, unlike severe valvular aortic stenosis, will not produce a paradoxical split of S2. Unfortunately, cases of aortic stenosis too mild to produce a paradoxical split of S2 can be very difficult to distinguish from aortic sclerosis.

Worse, in some cases of aortic sclerosis (proved by catheterization), the murmur radiated to the right midclavicle and was grade 3/6. This is especially likely with concurrent severe anemia. After transfusion, the murmur may diminish to grade 1/6, although the

[14] Negative likelihood ratio, as previously noted, is the applicable likelihood when a finding (such as radiation of a murmur to the right carotid) is absent.

radiation and amplification persist. Although intellectually it seems obvious that the synergistic effects of turbulence and high flow could produce such a mimicking of the murmur of significant valvular aortic stenosis, it can be quite startling to hear in real life.

A Caveat. We are speaking here of the difference between severe valvular aortic stenosis (as epitomized, say, by rheumatic valvular disease) and very mild degrees of degenerative sclerosis of the aortic valve, which cause roughening and a murmur but no obstruction. It should be pointed out that with the passage of time, the sclerotic process can itself evolve into an obstruction process, and the distinction can no longer be made by physical examination or much else short of direct inspection of the valve.

Aortic Stenosis Mimicked by Mitral Insufficiency

When the systolic regurgitant jet squirts back into the left atrium and vibrates the aorta opposite the enlarged left atrium, these vibrations may be heard at the aortic root area as a diamond-shaped systolic murmur, as documented by intracardiac phonocardiography (Antman et al., 1978).

Nonvalvular Lesions

Obstruction to the aortic outflow tract may also occur above the valve (supravalvular aortic stenosis) or below (subvalvular aortic stenosis, generally known as IHSS; *vide infra*).

Depending on the location of the supravalvular stenosis, these rare patients may have a coarctationlike picture. Sometimes the blood pressures in the two arms are unequal. Many of these congenital anomalies can be traced to bouts of maternal hypercalcemia. As infants and children, these patients are thought to show elfin facies and a "machinelike" sound to the speaking voice, but this stereotype should not be relied on for diagnosis in an adult.

Idiopathic[15] Hypertrophic Subaortic Stenosis

An Overview

In the platonic (ideal) form of IHSS, there is a ring of cardiac muscle just beneath the valve that contracts in systole, so that the wall of the ventricle forms an obstruction to its own outflow (Fig. 17-11).

IHSS receives more attention in this chapter than it deserves from the standpoint of its prevalence because it is so epistemologically useful when contrasted to valvular aortic stenosis of either the rheumatic (now waning) or the bicuspid (now waxing) type. Additionally, hypertrophic cardiomyopathy is the most common cause of sudden death in young competitive athletes, so it is very important when it does occur (Maron et al., 1995).

In point of fact, the question of IHSS is much more complicated and evolving than suggested here. Related issues include the morphology of the muscle wall, the condition of the coronary circulation, and the diastolic filling abnormalities. Also, it is increasingly being recognized that in many cases of IHSS, the obstruction is not caused by a ring of muscle, but by contact between the septal leaflet of the mitral valve and the outflow tract (Wigle, 1987). (The midsystolic diamond-shaped ejection murmur occurs in both types.) However, the entity was first appreciated in terms of the dramatic physical findings of IHSS and is considered here from this viewpoint. The reader interested in learning more is advised to read almost anything by S.E. Epstein (e.g., Maron et al., 1987).

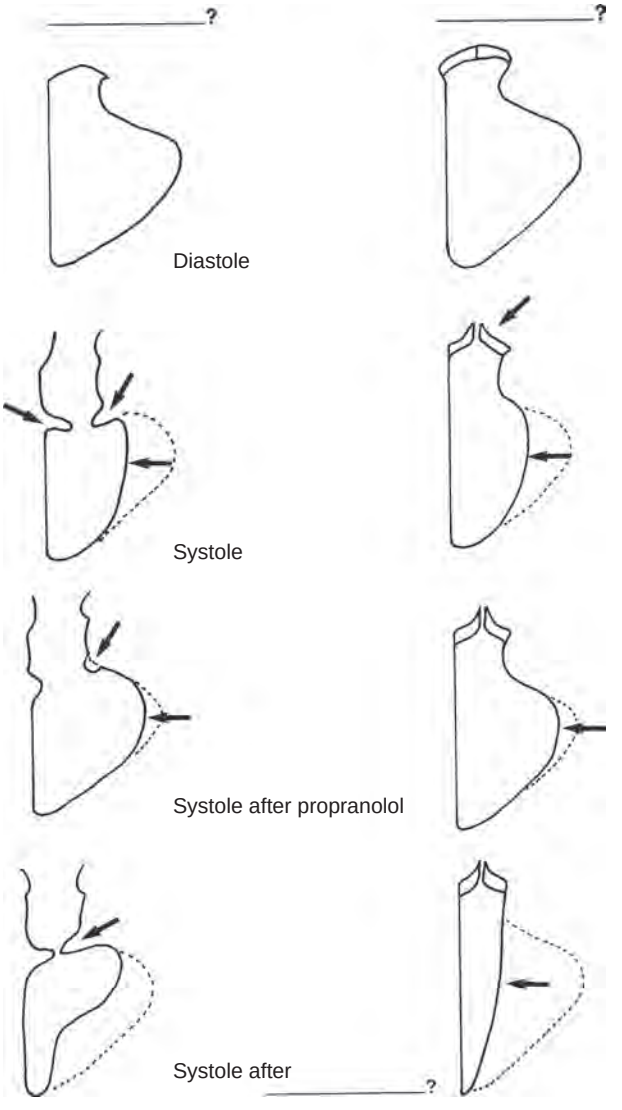


Figure 17-11 A diagrammatic representation of two lesions. Can you fill in the blanks? (Answer in Appendix 17.4.)

Subaortic Muscular Stenosis

Very Advanced. The symmetric ring of muscle that produces obstruction should probably be referred to as subaortic muscular stenosis. This should be distinguished from hypertrophic obstructive cardiomyopathy, in which the entire left ventricular wall is hypertrophied (Goodwin, 1972). Although there are overlaps, both of these may be different from the entity asymmetric septal hypertrophy, in which there is no apparent involvement of the free wall of the left ventricle. A partial outflow obstruction can occur in patients with an asymmetric hypertrophy of the muscle on the septal side of the outflow track. However, in some cases, asymmetric septal hypertrophy may apparently progress to subaortic stenosis. In other cases, it

[15] You should pardon the expression (see Appendix 7.4, Chapter 7).

occurs in families, in which the abnormal genotype may manifest either as asymmetric septal hypertrophy or as subaortic stenosis in different individuals (Maron and Epstein, 1979).

For the Attending. Whatever you do, you must not begin every sentence with "I can remember when I was a student…." Therefore, I would not dare tell the following story to anyone under the age of 40.

When I was a student, Drs Jack Myers, Eddie Fisher, et al., published one of the first cases of IHSS. I can still recall the debate that occurred in the student lab (where we did the routine hemoglobin, hematocrit, white blood cell count, differential, and urinalysis) as to whether or not it was worth learning about this entity, which appeared in none of our texts. The naysayers won the day, arguing that if it took such luminaries so much time to find a single case, it could not be a very important disease. Although this story seems to me to be of value to younger persons, it only bores them. As Dr David Oldach of Maryland once said to me, "Please don't tell us such things. Let us learn them for ourselves." Still, like Ovid, sometimes I cannot take my own advice and so apologize with La Rochefoucauld's "*Peu de gens savent être vieux*" (few of us know how to be old).

Importance of Establishing the Diagnosis

Distinguishing valvular aortic stenosis from IHSS has important therapeutic implications, which might be predicted from the response of the murmurs to various maneuvers. A patient with IHSS would do worse on digitalis because of the increased contraction of the subaortic muscle ring. A patient with aortic stenosis would not get worse on digitalis, although his condition might not be improved. Conversely, the administration of propranolol to a patient with aortic stenosis might decrease inotropy sufficiently to cause congestive heart failure, whereas beta-blockers are a desirable therapy for IHSS, as they decrease the degree of dynamic obstruction.

Clinical Findings

One way to distinguish valvular aortic stenosis from IHSS on physical examination is by the carotid upstroke (see Chapter 18). Another way is to note the intensity of the second heart sound. It is usually louder in IHSS than in true valvular aortic stenosis.

Third, the murmur of aortic stenosis decreases with standing, whereas that of IHSS increases, as noted above, because of the decrease in filling pressure. In IHSS, there is more of a gradient across the obstruction when the ventricle is less expanded. This effect is partly related to a change in contractility but is conveniently remembered by thinking that the stenosing lips of the muscle have less distance to travel and therefore create a more effective stenosis if the ventricular chamber is small (Fig. 17-11). If the murmur increases in intensity with squatting, the likelihood of hypertrophic cardiomyopathy decreases significantly (likelihood ratio 0.15) (Etchells et al., 1997).

Fourth, as expected from the fact that standing and squatting have opposite effects on ventricular filling, the murmur of IHSS may get softer with the patient squatting (Rothman and Goldberger, 1983), whereas that of aortic stenosis usually does not. If the murmur decreases or remains unchanged with squatting, then hypertrophic cardiomyopathy is considerably more likely (PLR 4.5). For the same reason, if the murmur decreases with passive leg elevation, the PLR for IHSS is 8.0 (Etchells et al., 1997).

Fifth, the murmur of IHSS gets softer during the post-Valsalva release (see Fig. 6-7), whereas the murmur of valvular aortic stenosis gets louder. This effect may also be comprehended in terms of ventricular filling and an increased end-diastolic volume. (With respect to the caveats about the Valsalva maneuver given above, note that we have specified the phase.)

Sixth, the murmur of aortic stenosis is loudest over the aortic valve area, but the murmur of IHSS may actually be loudest at the left sternal border.

Seventh, if an ejection click is present, valvular aortic stenosis is likely.

Eighth, if you are able to hear the heart during a spontaneous extrasystole (or, rarely, an extrasystole induced by rapping on the chest), it will be noted that the murmur of IHSS gets louder during the extrasystole, whereas the murmur of aortic stenosis gets softer. However, the murmur of valvular aortic stenosis will be louder during the immediate postextrasystolic beat. You would expect the murmur of IHSS to become softer during the postextrasystolic beat, but this finding is unreliable; the murmur is also longer (as shown by recordings), and some auscultators perceive the "longer" to be louder. During the postextrasystolic beat, the pulse pressure regularly becomes less in IHSS. This (the Brockenbrough sign) can sometimes be felt as a diminished pulse at the bedside (Kramer et al., 1986).

False Positives

Be aware of the "detection" of this "lesion" by echocardiography in many persons who do not have it, owing to the phenomenon of the angled septum (Fowles et al., 1980). Such patients do not have the murmur either, but it is difficult to impress house staff who "heard" the murmur because they first read the echo report. This is analogous to hearing the nonexistent S4 (Jordan et al., 1987).

In this connection, I have noticed the credibility hierarchy, a ranking of diagnosers of valvular heart disease, arranged in order of decreasing credibility:

1. A visiting professor (that is, a stranger in town who carries a slide case)
2. "Cardiology" (not the discipline, but a piece of paper typed by a secretary who may or may not have understood the dictation correctly)
3. The cardiology fellow (who started last month and has not yet been found to have hearing loss)
4. Student Schwein (whose sister dated the cardiology fellow from St Hellebore, last year)
5. The attending physician (who has not yet developed a reputation but who did go to the bedside and personally examined the patient with all present).

This is mentioned not only because I have occupied roles 1 and 5 within the same week, but also because the hierarchy is in exact inverse order of ease and accessibility for testing the accuracy of the findings by means of direct comparison *tête-à-tête*.

Mitral Insufficiency

Clinical Findings

The clinical findings in mitral insufficiency will vary somewhat with the etiology (*vide infra*). The characteristics of the murmur are described previously in this chapter. The most helpful differentiating feature is that the mitral insufficiency murmur tends to radiate to the axilla.

A comatose patient with a history of hypertension and a previous myocardial infarction had a systolic murmur, thought by house staff to be that of aortic stenosis. On auscultation, a grade 3/6 coarse ("white noise") holosystolic murmur could be heard over the apex. It radiated weakly to the left axilla (where it was grade 2/6) and to the back (grade 1/6) but not to the right midclavicular area. What is your diagnosis? (Write it down.)

Because the murmur was holosystolic and was not heard at the right midclavicular area, it was not consistent with aortic stenosis. The apical location and the radiation to the axilla were not suggestive of tricuspid insufficiency. One did not diagnose ruptured ventricular septum because the murmur was louder in the axilla than posteriorly and because Friedberg (1956) and others have encountered proved mitral insufficiency murmurs that radiated to the back. One diagnosed mitral insufficiency, correctly, as it turned out. More commonly in this situation, the murmur is a diamond-shaped murmur, rather than a holosystolic one. Could you then recapitulate the above reasoning? Try it. (Check your answer in Appendix 17.5.)

Etiology

An Overview

Mitral insufficiency can either be primary (usually with a holosystolic murmur) or secondary to some other process that leads to a failure of perfect coaptation of the leaflets of the mitral valve.

Primary mitral insufficiency is a common manifestation of rheumatic fever, still common in some areas of the world and perhaps recrudescing in the US. Rheumatic carditis should still be considered if a patient develops a new apical systolic murmur, with or without an accompanying apical middiastolic murmur and/or basal diastolic murmur (American Heart Association, 1992). Currently, the most common single cause is probably mitral valve prolapse. Other causes include infective endocarditis, trauma, carcinoid syndrome with either an atrial septal defect or pulmonary involvement, systemic lupus erythematosus, rheumatoid arthritis, ankylosing spondylitis, Marfan syndrome, Ehlers–Danlos syndrome, pseudoxanthoma elasticum, and various congenital malformations of the mitral valve.

Secondary mitral insufficiency is most frequently caused by either papillary muscle dysfunction or cardiomyopathy (or other types of congestive heart failure), wherein the heart (including the mitral annulus) enlarges beyond the competence of the mitral valve (which cannot enlarge concordantly). Papillary muscle dysfunction may ultimately be caused by acute ischemia or infarction, or even chronic infarction of the papillary muscles. Besides dilated, hypertrophic, or restrictive cardiomyopathy, causes of a dilated mitral annulus include mitral annular calcification and radiation therapy.

Other etiologies that are not unanimously classified as to type include mucocutaneous lymph node syndrome (Kawasaki disease), osteogenesis imperfecta, some of the mucopolysaccharidoses, and Fabry disease (Olson et al., 1987).

General Principles Illustrated by Developing Knowledge on Rupture of the Chordae Tendineae

Rupture of the chordae tendineae may sometimes be the mechanism for the mitral insufficiency in several of the conditions listed above, including the connective tissue disorders and infective endocarditis, although chordal rupture is usually "spontaneous" (i.e., of unknown etiology). Originally, it was believed that this disease presented with a dramatic acute onset, a "whirring" systolic murmur due to the ruptured chordae being spun in the regurgitant jet of blood, and pulmonary edema leading to death if surgical intervention was not undertaken. We now know that the disease is usually less dramatic at onset, does not always produce the whirring holosystolic murmur, and is usually a progressive disease rather than an acutely fatal one (Oliveira et al., 1983).

This disease thus illustrates an important principle of medicine: when new diseases are constructed and described, inevitably, the very worst cases are reported first. After the picture of a flagrant disease with high mortality and morbidity is set in the literature, later series note severe cases. By then, however, it is difficult to convince people that the original descriptions were only one part of the spectrum of disease.

The corollary to this is that relatively rare diseases, of which the average physician is unlikely to see many cases, will have their original noxious image persist in the medical public's mind much longer than that of more common diseases. The latter will more likely permit consensual validation of the existence of a class of patients whose state is more benign than the original description.

A second corollary, more subtle but more important, is that in the study of the therapy of a disease, one should not use historic controls. If one does not have a concurrent control group but instead gives all current patients a new remedy and compares their outcome with the outcome of patients studied before the remedy became available, it is easy to be misled. Current patients are probably less severely afflicted than those diagnosed when the disease was first described and will seem to "do somewhat better" on any equivalent new therapy.

A subcorollary is that for relatively rare diseases, for which the average physician is most dependent on the literature reports of others, this shift in the description of the natural history is least likely to be appreciated. Thus, if remedies for a very rare disease are compared using historic controls, the new remedy is likely to appear much better than the old therapy, even if both are actually of equal efficacy.

Mitral Valve Prolapse

The regurgitation in some cases of mitral valve prolapse might depend on no actual valvular lesion. Relaxation of the walls of the ventricle or of the papillary muscles might allow some slight regurgitation during a portion of the systolic period (Griffith, 1892).

Variability of the Murmur

The honk or whoop or coo of mitral valve prolapse may vary from beat to beat, this variability being one of the factors that led early auscultators to doubt a cardiac origin. The variability, when it is present, results from the fact that the prolapsed mitral valve is like a clarinet reed and can only be sounded when the d*P*/d*t* is perfect for that reed. Because there is a slight beat-to-beat variation in the amount of blood flow and the d*P*/d*t* across the valve (in systole), there may be a wide variation in the resulting sound. With some honks, the variation in d*P*/d*t* causes a variation in timbre, so that one may hear a goose on one beat and a pigeon on the next. In some patients, the honk is heard only during premature ventricular contractions. At other times, the overriding influence is the venous return to the left side of the heart, so the variability is a function of respiration, and one hears the sound only with one phase of respiration. Thus, it is easy to see how the honk was once thought to be of pulmonary origin.

In addition to mitral valve prolapse and tricuspid valve prolapse, a honk has also been detected in cases of infectious endocarditis of the mitral and tricuspid valves and in presumed mitral annulus dysfunction secondary to primary myocardial disease or ischemic heart disease (Sheikh et al., 1984). It is interesting that whereas the honk is more pronounced (or appears exclusively) with standing in the case of prolapsed mitral valve, in the other causes of "honking" on standing, the honk actually disappeared or decreased in intensity, but never appeared or became louder.

A Caveat. However, most prolapsed valves cause murmurs of the usual type and not bird songs. To recapitulate changes with position: with standing, the murmur comes earlier and lasts longer because of lowered venous return. If there is a click, it comes earlier also. With squatting, the click comes later, with a shorter murmur. The murmur never has an ejection configuration but always runs into S2.

Systolic Clicks

Mitral valve prolapse may be associated with a systolic click, by a mechanism illustrated in Fig. 17-12.

The click precedes the murmur. (Thus, the murmur, if accompanied by the click, cannot be holosystolic, as the portion of systole between the first heart sound and the click is silent.)

One should always auscultate for mitral valve prolapse with the patient in the *standing position* because the murmur may become louder and/or longer (Rothman and Goldberger, 1983). Also, with standing, the ejection click may occur earlier in systole (p. 290) or appear if it was previously absent (Popp and Winkle, 1976).

There are patients who have only the ESC and no murmur. There have even been patients with prolapse seen on echocardiography who have no murmur and no click, and some patients will have one set of findings at one point and another when studied later in the same position. (Forget this while you solve the problem given in the next paragraph.) (Note, however, that it is possible to produce "echocardiographic mitral valve prolapse" by an abnormal inferiorly directed orientation of the transducer [Cheng, 1987].)

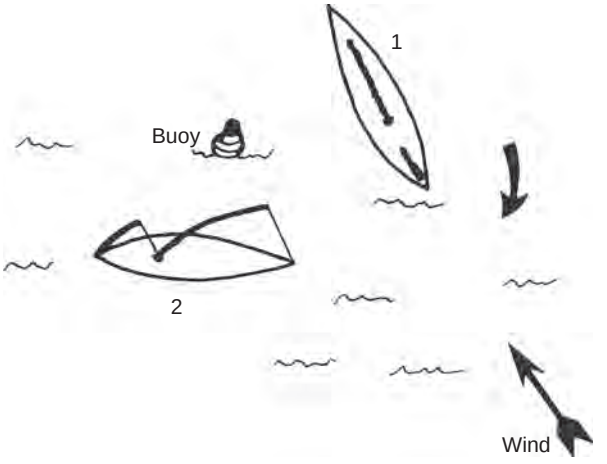


Figure 17-12 Mechanism for the systolic click in mitral valve prolapse. Look at sailboat 1, which is just coming around the mark (buoy). The wind is out of its sails. Soon it will turn into the position of sailboat 2, the sails of which are completely filled by the wind. If the sails on the first boat abruptly catch the wind as it turns into position, there will be a snapping or popping sound. This is analogous to the click heard in mitral valve prolapse. Obviously, if the sailboat rounds the mark very slowly, and the sails fill out gradually, the same excursion will not necessarily produce a snap or a pop just as mitral valve prolapse is not always accompanied by a click. This should also explain why the presence or absence of a click is unrelated to the presence or absence of a murmur.

Epidemiology

With the irruption of echocardiographers, mitral valve prolapse could be diagnosed in the absence of a click or a murmur. In fact, only 9% of patients with mitral valve prolapse found in the Framingham study (Savage et al., 1983) had clicks and 9% had murmurs. Only 2% had both findings. Conversely, this study revealed that only 50% of people with clicks alone had echocardiographic mitral valve prolapse, although the additional presence of the murmur made the diagnosis more certain. In the free-living population without recognizable mitral valve prolapse, 1% had clicks and 3.53% had murmurs (Savage et al., 1983).

Self-test

If the prevalence of mitral valve prolapse in Framingham was 7.11% and the number of subjects was 2,925, calculate the murmur's positive PV for mitral valve prolapse and the negative PV of no murmur. Answers are in Appendix 17.6.

Prognosis

The clinical findings in mitral valve prolapse are helpful in predicting adverse outcomes, including death, stroke, endocarditis, or progressive mitral regurgitation requiring surgery. If a holosystolic murmur is present, the PLR for an adverse outcome is 18.0. The presence of any click reduces the likelihood ratio to 0.26 to 0.4. The absence of a click or murmur in a patient with echocardiographic mitral valve prolapse reduces the likelihood ratio of adverse outcome to a mean of zero (95% confidence interval 0.0 to 4.1; Etchells et al., 1997).

History

For the neophyte who believes that diseases are fixed and easily discoverable entities, the story of mitral valve prolapse may substitute for the sad sense of history possessed by the quinquagenarians who have lived long enough to see their investigative techniques tarnished, their specialty transformed in the maelstrom of time, and their pet "diseases" as prevalent as the schottische.

Mitral valve prolapse, currently the most common of mitral valve diseases, said to afflict 4% of the population, did not appear in any of the pathology, medicine, or cardiology textbooks of my school days! For many years, it was known that tall, thin, ectomorphic, asthenic, apparently healthy patients who had a very straight thoracic vertebral column, an anterior–posterior/transverse thoracic diameter less than expected, and sometimes pectus excavatum, might also have a systolic murmur over the mitral valve area. These patients were said to have the "straight-back syndrome." It was assumed that their apical systolic murmur was caused by the heart being squeezed between the sternum and the straight back. The straightness of the back was easily demonstrated by observing it from the side when the patient raised his arms or by a lateral chest film. From the days when Grand Rounds were still grand and rounds, I can remember learned cardiologists demonstrating the bedside diagnosis of this syndrome in patients about to be freed from the onerous burden of the diagnosis of heart disease. The learned discussers would point out the lack of historic evidence of heart disease (such as cyanosis or rheumatic fever); the absence of physical findings other than the systolic murmur; the total absence of electrocardiographic findings (except for "clockwise rotation of the heart," a diagnosis that is now as obsolete as the pterodactyl); and the altered cardiac borders on the PA chest film (further evidence that the heart was "trapped" between the sternum and the straight back).

At the same time, there was another entity that was also believed to be artifactual in nature. Auscultating the hearts of some patients, one could hear a "whoop" or a "honk." These sounds were described as short musical cries but were not believed to be cardiac in origin, as they were not present during every cardiac cycle. The noises were sometimes preceded by a systolic click, a phenomenon that had also been noticed in patients with a straight-back syndrome. (However, in the latter case, the click was considered to be an innocent aortic sound demonstrating the good function of the heart, and in no way related to the murmur, which was considered nonpathologic albeit cardiac in origin.)

As the reader has already guessed, the "honk" or "whoop" was definitely of cardiac origin (Behar et al., 1967). This was demonstrated by intracardiac phonocardiography, by angiography, and (very rarely) by autopsy, which revealed the same lesion ("ballooned mitral valve") seen in patients with Marfan syndrome and mitral insufficiency. Eventually, it was noted that patients with such "parachute" mitral valves (later included in the set of mitral valve prolapse) could have the systolic click and murmur without a honk or a whoop. Then, it was observed that many of these patients, although not having Marfan syndrome, did have a marfanoid appearance, that is, their skeletons resembled those of patients with the presumably benign straight-back syndrome. At the same time, other workers, building up the other side of the corbelled arch, showed that thoracic cage abnormalities were frequently accompanied by mitral valve prolapse. Finally, we began to realize that the patients with the so-called innocent straight-back syndrome actually had no such "syndrome" but merely manifested the thoracic skeletal signs of the same connective tissue disease diathesis as their mitral valve prolapse (Bon Tempo et al., 1975; Salomon et al., 1975).

Associated Findings

In addition to pectus excavatum, scoliosis, and the habitual signs of the straight-back syndrome (*vide supra*), women with mitral valve prolapse will have an increased prevalence of small breasts, and women with small breasts have an increased prevalence of mitral valve prolapse (Rosenberg et al., 1983).

Associated Diseases

Mitral valve prolapse may also occur in association with Marfan syndrome, Ehlers–Danlos syndrome, von Willebrand syndrome, pseudoxanthoma elasticum, osteogenesis imperfecta, adult polycystic renal disease, some cardiomyopathies, and several types of congenital heart disease (Olson et al., 1987), including secundum atrial septal defect (Cheng, 1987).

Associated Neuroses

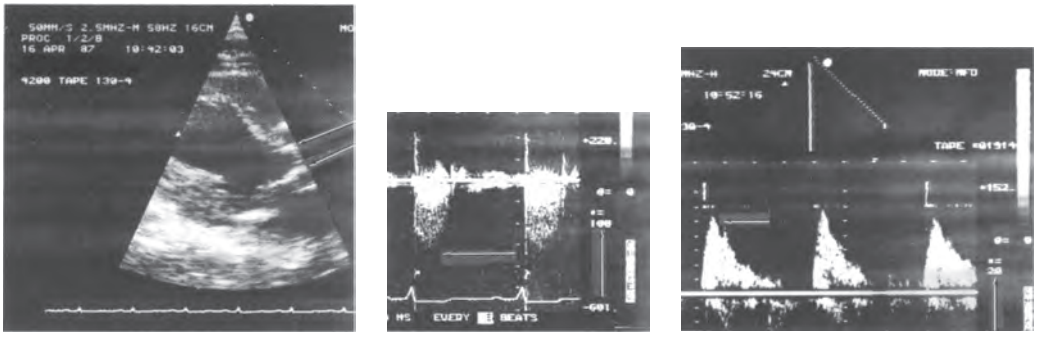
The newest finding seen as part of the mitral valve prolapse syndrome is agoraphobia; this might be related to the tachyarrhythmias to which patients with mitral valve prolapse are subject (Kantor et al., 1980). However, this association between agoraphobia and other neuroses in mitral valve prolapse has been questioned (Hickey et al., 1983). Who is correct?

As a general rule, we follow Claude Bernard in asserting that both are correct, the difference between the two results due to unstated differences in the experiments that were done. Here, the disparate origins of the populations sampled represent a fertile source of unstated differences.

In other studies, patients with various psychiatric disorders, such as anorexia or bulimia (Johnson et al., 1986), have been found to have a greater prevalence of mitral valve prolapse than a control group. The most interesting paper of this type finds that the incidence of mitral valve prolapse in anorexia nervosa varies inversely with the weight of the subjects. The authors reasoned that as the subject lost weight and the left ventricular end-diastolic dimensions decreased, the mitral valve, not shrinking comparably, became redundant. When the subject gained weight, those cardiac dimensions also increased and took up the slack in the prolapsed valve (Meyers et al., 1986). To the degree that this finding can be replicated and extended, we are faced with the novel proposition that mitral valve prolapse is a state, not a trait. This raises another of those philosophical questions so plentiful in medicine: if something is a state, not a trait, is it truly a disease, or is it a diathesis?

Mitral Valve Rupture

In acute severe regurgitation due to mitral valve rupture, the murmur will not be totally pansystolic but will end with a sudden drop-off in intensity—a cigar shape—because of the high end-diastolic pressure. Dr Phibbs had a patient with this finding whose mitral bioprosthesis had "gone west," with a torn leaflet.



A B C

Figure 17-13 **A:** Echocardiogram. Arrows point to calcification in the aortic valve. **B:** Calculating the gradient from the Doppler envelope: the arrows point to the number "100" in the lower right-hand corner and to the Doppler envelope, displayed negatively. The "100" is the scale setting and means that each mark is 100 cm per second velocity or 1 m per second. The modified Bernoulli equation states that the maximum velocity in meters per second, squared, times 4 equals the gradient in mm Hg. Now, look at the horizontal arrow. The peak velocity is 320 cm per second or 3.2 m per second, so the gradient = (3.2)(3.2) × 4 = 41 mm Hg, a moderate degree of aortic stenosis. **C:** A special Doppler study of the mitral valve. The vertical arrow shows that the scale has been adjusted to 20 cm per second. Five marks tells us that the maximum velocity is 100 cm per second or 1 m per second. Therefore, the "gradient" is (1)(1) = 4 mm Hg (i.e., no gradient to speak of). This is an example of physiologic or "false-positive" mitral insufficiency by Doppler (Table 17.8).

When Is a Mitral Insufficiency Murmur Not Mitral Insufficiency? (The Gallavardin Phenomenon)

Calcific aortic stenosis is most likely to produce the Gallavardin phenomenon. The Gallavardin phenomenon is a change in the pitch and timbre (but not shape) of an aortic valvular stenosis murmur with location, so as to imitate coexistent mitral regurgitation. That is, at the aortic area, the murmur is heard as harsh and dirty, but as one inches down to the apex, the timbre and tone become more pure, musical, and high pitched, imitating mitral insufficiency. The rough murmur originates from the turbulent blood flow at the aortic root, whereas the high-pitched musical murmur at the apex must come from the harmonic echoes from the symmetric fibrocalcific cusps, analogous to the situation in which a human voice echoes from the walls of a canyon. It is important to know of this phenomenon because otherwise the auscultator might falsely believe that the two different murmurs (differing in pitch and timbre) represent two different lesions, and so, incorrectly diagnose mitral insufficiency in addition to the true aortic stenosis (or, uncommonly, sclerosis).

For the Attending.

1. The pathophysiology of the Gallavardin phenomenon may not be quite as simple as I have just implied. Gallavardin believed that it reflected the preferential transmission of the harmonic high-pitched components to the apex through solid tissue, whereas the lower components were transmitted to the neck via the flow of blood (Gallavardin and Ravault, 1925). To my knowledge, this testable hypothesis has been neither refuted nor further examined. Gallavardin's own belief is close to the theory of Bruns (1959), which is both general and exact. However, it would not necessarily explain why the Gallavardin phenomenon is always associated with aortic valve calcification.

   There is evidence in at least one case that the murmur was actually caused by the mitral insufficiency of papillary muscle dysfunction (Giles et al., 1974), yet this cannot be the explanation in all cases. I have had patients with the Gallavardin phenomenon who had no papillary muscle dysfunction (i.e., no mitral insufficiency) when examined by Doppler ultrasound (*vide infra*). Perhaps there is more than one Gallavardin phenomenon.
2. A 64-year-old white man with known coronary artery disease and angina was noted to have the "murmur of mitral insufficiency" on one of many admissions. In fact, the patient had a diamond-shaped murmur heard at the apex, but he also (when auscultated in a quiet room) had a coarse basal systolic murmur with right midclavicular amplification. The diagnosis of Gallavardin phenomenon was considered so bizarre by the house staff that they actually wagered on the Doppler studies and gave odds to boot.

The predicted calcification of the aortic valve is shown in Fig. 17-13A. The gradient across the valve can be calculated from the Doppler envelope shown in Fig. 17-13B (see legend), revealing a moderate degree of aortic stenosis.

Does this prove that the patient did not also have mitral insufficiency? It does not. Also, the peak Doppler velocity overestimates the aortic gradient as determined at catheterization (Krafchek et al., 1985). So a special search was instituted for mitral insufficiency, and it was not seen on echo. A special Doppler study did show "mitral insufficiency," as demonstrated in Fig. 17-13C (see legend), but the "gradient" of 4 mm Hg is not significant. (Such "physiologic" mitral and tricuspid "insufficiency" is often found by Doppler in the absence of any physical signs or other evidence of valvular disease [Table 17.8].)

Mitral Stenosis

Clinical Findings

Auscultation

Mitral stenosis has traditionally been associated with four auscultatory findings: a cracking, loud S1; a loud S2 (from an increased P2 supposedly reflecting pulmonic hypertension); an opening snap; and the classic diastolic murmur.

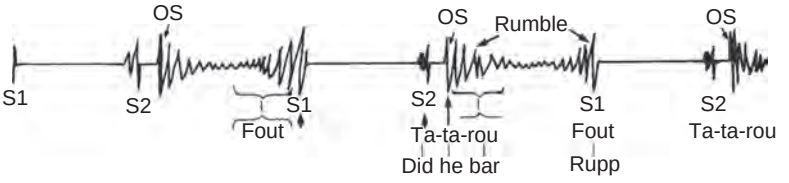


FIGURE 17-14 Phonocardiographic findings in pure mitral stenosis (see text).

In point of fact, no correlation has been demonstrated between the amplitude of the pulmonic valve closure sound and the pulmonary artery pressure. Rather, the amplitude of P2 correlated with the degree of the patient's skinniness. There was also no significant correlation between the amplitude of S1 at the apex and the severity of the mitral stenosis. In fact, S1 could be soft or inaudible with mitral valve calcification (Surawicz et al., 1966). The opening snap was present in 90% of the patients with pure mitral stenosis and noncalcified mitral valves, but this finding was lost with increasing calcification and so was more likely to be present in milder cases (Surawicz et al., 1966). Thus, Tavel detected an opening snap in only 75% of all his cases (Reddy et al., 1985). There were only 2 of 141 patients with mitral stenosis who did not have the diastolic murmur, which is, therefore, the "best" sign (Surawicz et al., 1966). However, the presystolic component may be inaudible when atrial fibrillation supervenes.

Methods of augmenting the mitral stenosis murmur are discussed previously in this chapter.

The phonocardiographic findings of mitral stenosis are diagrammed in Fig. 17-14. The auscultatory findings were imitated by Duroziez with the phrase "*fout ta-ta rou*" (say it out loud, please). By this, he meant that the presystolic late diastolic crescendo murmur ending in a cracking S1 could be represented by the word "*fout*." The "*ta-ta*" represented the loud S2 followed by the opening snap. Finally, the "*rou*" coming off the opening snap is the early diastolic decrescendo murmur. Those who have heard the murmur of mitral stenosis can appreciate that Duroziez's phrase is a wonderful verbal mimicking of the sound. However, it does not seem to have caught on in the English-speaking US. Accordingly, I propose an English language equivalent:

The owner of the now-defunct Stork Club in sophisticated New York City was notorious for barring certain persons from entering. We might wonder what would have happened if the University of Kentucky's bucolic basketball coach, Aldolph Rupp, had attempted to get in. About the owner, we would have asked: "Did he bar Rupp?" Here, the first two words substitute for the "*ta-ta*," being the S2 and the opening snap, respectively. "Bar" refers to the early decrescendo component of the diastolic murmur, and "Rupp" is the late diastolic component crescendoing to the cracking S1.

So far, we have been discussing mitral stenosis with normal sinus rhythm. In that instance, the sound sequence of mitral stenosis can be reasoned out. When atrial fibrillation supervenes, however, the delirium cordis produces auscultatory phenomena so chaotic that the neophyte cannot possibly hope to reason them out. Accordingly, this is the only auscultatory phenomenon that one must memorize. Obtain a tape recording or phonograph record of mitral stenosis in the presence of atrial fibrillation and memorize the sound.

A verbal imitation might be obtained by quickly repeating several times the following phrase, with its odd unpredictable sequence of rumblings and snappings: "In Walla Walla, Washington, my pocket was picked as I watched the Walla Walla cricketers rub wickets."

Associated Findings

Although much has been written of the malar flush (see Fig. 9-9A) in mitral stenosis, this was seen only in very severe cases, which nowadays have been detected and surgically treated prior to that clue's appearance. (The malar flush can also be seen in pulmonic stenosis, without mitral stenosis.)

Etiology

Although mitral stenosis was probably of rheumatic origin in 99% of patients in a surgical series, other causes have been reported. These include massive annular calcification, infective endocarditis with large obstructing vegetations, systemic lupus erythematosus, rheumatoid arthritis, gout, amyloidosis, Whipple disease, methysergide therapy, carcinoid syndrome with associated atrial septal defect or pulmonary involvement, mucopolysaccharidoses, Fabry disease, pseudoxanthoma elasticum, and congenital mitral stenosis (Olson et al., 1987).

Differential Diagnosis: When Is the Mitral Stenosis Murmur Not from Valvular Mitral Stenosis?

1. The Flint[16] murmur is a presystolic (that is, late diastolic) murmur sounding just like the presystolic rumble of mitral stenosis in a patient who has aortic insufficiency but no anatomic stenosis of the mitral valve. In diastole, the regurgitant jet of blood coming back into the left ventricle through the incompetent aortic valve keeps the anterior mitral leaflet from its full diastolic excursion. In mechanistic terms, this regurgitant jet holds the anterior mitral leaflet in a relatively "closed" (stenotic) position throughout diastole (Weir and Dargie, 2008). At the end of diastole when the atria contract, the blood expelled from the left atrium into the ventricle is obstructed by this anterior mitral leaflet, and turbulence and a murmur are created, just as if the anterior leaflet of the mitral valve were being held in a closed ("stenotic") position from actual rheumatic scarring. Thus, mitral stenosis is not mitral stenosis when it is due to the effects of the regurgitant jet of aortic insufficiency. (To distinguish the Flint murmur from valvular mitral stenosis at the bedside, see later in this chapter.) Yes, there can be a right-sided Flint murmur (Kambe et al., 1979).

2. Between 1958 and 1971, I saw Dr Myers of Pennsylvania make only four or five diagnostic errors, one of which was to diagnose

[16] Not Austin Flint. There was no Dr Austin anymore than there was a Dr Jod (see Chapter 14). Austin was his first name. We will meet two more nonexistent cardiologists shortly.

mitral stenosis on the basis of a rumbling diastolic murmur in a case of pure mitral insufficiency. He was so sure of his diagnosis that he accused the pathologist of missing the lesion. The pathologist retorted that he had noticed that all examiners had heard the classic rumble, but a careful search of both mitral and tricuspid valves had revealed only mitral insufficiency.

We now know that relative mitral stenosis can occur in a situation in which there is no structural mitral stenosis (Fortuin and Craige, 1973). Just as the increased stroke volume produced by aortic insufficiency can cause an aortic stenosis murmur, the increased left atrial stroke volume due to mitral insufficiency can cause turbulent blood flow and a rumble.

A few years later, Dr Myers himself was teaching about the relative mitral stenosis of increased flow. The auscultatory result might be described as an "S3-rumble complex" or an opening snap with an early diastolic rumbling due to exaggerated flow (J.E. Atwood, *personal communication*, 1998).

This story illustrates two points: (a) the really good diagnosticians are the ones who can reprogram their brains and (b) the rumble of mitral stenosis must be extremely specific if it took such an adept clinician so long to learn the exception to the rule.

Very Advanced. The diastolic flow murmur of relative mitral stenosis occurring in acute rheumatic fever is specifically called the *Carey Coombs murmur* after the one doctor who described it. (Right, there was no Doctor Carey!)

3. A case for a clinical pathologic conference (CPC): A 55-year-old previously healthy woman (specifically, with no history of asthma, allergies, rheumatic fever, or any pulmonary or cardiac disease) presented with a progressive illness of several months duration. It began with a cough, which was treated by a medical assistant with antibiotics despite absence of fever. When symptoms worsened, a physician prescribed a different antibiotic, followed by still another antibiotic. She developed exertional dyspnea, edema, heartburn, and epigastric distention. A chest physician treated her, ineffectively, with an inhaled corticosteroid, and she also received a codeine-containing cough suppressant. She was referred to a "refluxologist," apparently, a gastroenterologist specializing in gastroesophageal reflux, who made the diagnosis of that disease and prescribed Prilosec. The insurance company refused to pay for that drug, so she was advised to take Prevacid "for life." Her regular caregiver changed her to Zantac, still with no relief of her respiratory symptoms. She also developed orthopnea, postural dizziness, and intermittent precordial pressure, described by placing her fist over her xiphisternum. Apparently, she had an altercation with her insurer because of her visits to multiple physicians. As a last resort, she visited an "alternative medicine" clinic that specializes in nutritional therapy. Dr Dorman, the physician who attended her, noted the following findings on physical examination: BP 132/92; P 96; R 36; normal sinus rhythm; venous pressure of 22 cm; edema to the knees with a trace of presacral edema; slight bibasilar rales; an intermittent apical diastolic murmur; and a third heart sound.

What diagnostic test was ordered, and what diagnosis was made? (See answer in Appendix 17.7.)

Pulmonic Insufficiency

Clinical Findings

The murmur of pulmonic insufficiency, heard best in the second left interspace, tends to have a brief crescendo in the very beginning of diastole before it becomes decrescendo. However, the shape of the Steell[17] murmur (pulmonic insufficiency secondary to pulmonary hypertension) may be indistinguishable from that of aortic insufficiency. The Graham Steell murmur can be high pitched like that of aortic insufficiency, or it can be of a lower pitch.

The differential diagnosis of aortic from pulmonic insufficiency is given previously in this chapter.

Etiology

Pulmonic insufficiency, like other valvular abnormalities, may be considered to be either primary or secondary. Primary pulmonic insufficiency would be seen in a few cases of rheumatic heart disease and in some rare cases of infective endocarditis of the pulmonic valve. Since a major risk factor for infective endocarditis is now intravenous drug abuse, we should note that the endocarditis of the drug abuser usually (99% of cases) spares the pulmonic valve (Sapira and Cherubin, 1975). Syphilis also spares the pulmonic valve.

Secondary pulmonic insufficiency is known by the company it keeps. It may be the Steell murmur of pulmonary hypertension (which occurred in 12% of cases of mitral stenosis [Linhart, 1971]), or it may result from idiopathic dilation of the pulmonary artery or from the transient volume overload seen in patients with chronic renal failure (Perez et al., 1985).

Pulmonic Stenosis

Clinical Findings

There may be a right ventricular tap. S2 may sound widely split or single when P2 is softened to nothingness. The systolic murmur of pulmonic stenosis is maximal at the pulmonic area, but otherwise sounds similar to that of aortic stenosis. It may even radiate into the carotids, the left more than the right. The response to amyl nitrite may help differentiate isolated valvular pulmonic stenosis, infundibular pulmonic stenosis, and tetralogy of Fallot.

Etiology and a Consideration of Congenital Heart Disease

Pulmonic stenosis also may be either primary or secondary (relative). The primary form may be either congenital (with the murmur heard before age 5) or rheumatic (murmur first heard after the age of 5, in the presence of other valvular abnormalities because rheumatic fever rarely strikes only the pulmonic valve and infective endocarditis does not cause stenosis of this valve).

Secondary or relative pulmonic stenosis occurs in atrial septal defect and ventricular septal defect as long as the flow is

[17] Also called the "Graham Steell" murmur. As you have correctly guessed, there was no Dr Graham; it was Steell's first name.

from left to right. With ventricular septal defect, there may be a second systolic murmur due to the blood passing through the septal defect. One wishes to diagnose ventricular septal defect quickly, before the shunt reverses, not only because it is easier to do so then (before there can be confusion with tetralogy of Fallot), but also because surgical correction is most useful before the ominous supervention of pulmonary hypertension. The diagnosis of tetralogy of Fallot is suggested by the picture of a cyanotic patient with a ventricular septal defect and a single or very soft S2.

Atrial septal defect is characterized by a widely "fixed" split S2. It is different from probe-patent foramen ovale, in which an anatomic seal has not occurred. Probe-patent foramen ovale has no murmur or other physical findings, but, like atrial septal defect, it can be associated with paradoxical embolism (a venous embolus reaching the systemic circulation by passing through the foramen ovale). This happens if the foramen ovale opens, as it can whenever the right atrial pressure exceeds the left atrial pressure (e.g., in pulmonary hypertension with right-sided "backward" heart failure). This possibility is worth remembering because the prevalence of probe-patent foramen ovale is 34% during the first three decades of life, decreasing to 20% through the ninth and tenth decades (Hagen et al., 1984).

The persistence of the patent foramen ovale confers an increased risk of stroke (Horton and Bunch, 2004), decompression sickness and/or multiple brain lesions in sports divers (Knauth et al., 1997), and the fat embolism syndrome (Pell et al., 1993; Riding et al., 2004). If you think of the possibility, you can order the appropriate diagnostic tests: a transesophageal echocardiogram or a transcranial Doppler ultrasonogram following the peripheral injection of microbubbles (Schulte-Altedorneburg et al., 2003). The proper diagnosis could suggest a cardiac treatment for neurologic manifestations, such as anticoagulation or possibly transcatheter closure of the defect (Adams, 2004; Schräder, 2003).

This differential has covered all the major congenital defects, except two that you have already diagnosed: coarctation of the aorta (by taking the blood pressure in the leg) and patent ductus arteriosus (from the Gibson murmur, p. 361, Table 17.5).

Tricuspid Insufficiency

Clinical Findings

The Murmur

Tricuspid insufficiency causes a systolic murmur at the *left* sternal border in the fourth and fifth intercostal spaces, which usually does not radiate to the axilla.

Dr George Massing of Alabama taught me an important exception to the rule that radiation into the left axilla excludes the tricuspid valve as a source for the insufficiency murmur. In cases of severe pulmonary hypertension, in which the right ventricle changes from a volume chamber to a pressure chamber, it is possible for the murmur of mitral insufficiency to be mimicked by tricuspid insufficiency in every respect. In 1946, Carvallo described a highly diagnostic sign of tricuspid insufficiency: inspiratory augmentation (or appearance) of a systolic murmur at the lower left sternal border, due to increased filling of the right heart. The sensitivity is at least 61% (Gooch et al., 1983; Rothman and Goldberger, 1983), being higher in severe cases (Maisel et al., 1984). Unfortunately, inspiration tends to move the heart away from the examiner, counterbalancing the murmur's intracardiac increase. However, on those occasions when the sign is positive, it is highly significant (although there has been a documented false positive, that is, a patient who had the sign but not tricuspid insufficiency [Leon et al., 1965]).

Once you have detected inspiratory augmentation of the murmur of tricuspid insufficiency, its subsequent loss should suggest the possible supervention of right ventricular failure or some impediment to right ventricular inflow. The same probably holds for all the augmentation signs given in this section.

As previously noted, right-sided acoustic events may also be augmented or produced by increasing venous return, as by having an assistant rapidly lift the patient's legs into the air.

Another trick is the Vitums sign, taught to me by Dr Dan Cabaniss of Alabama. The appearance or increase in intensity of the typical murmur when squeezing down on the liver is presumptive evidence of tricuspid insufficiency. As with the Carvallo sign, this is probably highly diagnostic, although only 56% sensitive (Gooch et al., 1983).

Peripheral Venous Signs

1. Tricuspid insufficiency causes prominent systolic waves in the jugular venous pulse (CV merger; see Chapter 19).
2. Sometimes the murmur of tricuspid insufficiency, but not that of mitral insufficiency, can be detected over peripheral veins. Unfortunately, this sign has not caught on because of an apparent tendency for the neophyte to overdiagnose innocent cervical hums as a sign of tricuspid insufficiency. There are three ways to avoid this problem:
   a. Listen over a varicose vein in the leg. Unfortunately, this works only in patients who have varicose veins, and the test is helpful only when it is positive (Becker and Dick, 1962).
   b. Note the timing of the murmur. If it is continuous, it is a hum and cannot be caused by tricuspid insufficiency. On the other hand, if the murmur has the same timing and shape as the murmur you hear over the precordium, it is unlikely to be a venous hum.
   c. Occlude the venous system *distal* to the point at which you are listening. This will abolish a venous hum because the venous return can no longer rush past the point of obliteration and past your stethoscope on its way back to the right atrium. If the murmur persists, you know it must signify tricuspid insufficiency. This is true even if the intensity decreases somewhat, owing to the fact that the distal obliteration decreases venous deformability and so acts as an acoustic baffle. (Remember that in tricuspid insufficiency the murmur runs backward, from the systolic pressure head in the right ventricle back through the insufficient tricuspid valve into the right atrium and thence into the venous system.)

Expansile Liver

This sign is also based on the backward transmission of the pressure generated in the right ventricle during systole. It has been called the most dependable sign of tricuspid insufficiency (Dressler, 1950). An unequivocal pulsatile hepatomegaly

has also been reported in 35 of 55 consecutive patients with constrictive pericarditis (Naylor, 1994). The pulsations conform to the pattern of the jugular venous pulsations in the neck (with A and V waves and X and Y descents, as described in Chapter 19) and disappear after successful pericardiectomy (Manga et al., 1984).

So that you are not fooled by the aortic pulsations, try to get your fingers under the inferior edge of the liver. If the liver is truly expansile, it should move caudally during systole, in the same axis as the one in which the aorta lies. On the other hand, if you are merely feeling a transmitted aortic pulsation, the liver will not move down toward your fingers but rather will bound outward from the midline.

Better yet, if you can do it, surround as much of the circumference of the liver as possible with the spread fingers of two hands, with the hands as opposite to each other as possible. The center of the liver should be equidistant from each of the fingers, insofar as is possible. If the liver is truly expansile, your hands will be moved apart from each other during each systole. If, as is usually the case, the liver is not expansile, but rather the aortic pulsations are being transmitted, the liver will merely jerk in one direction during systole rather than expanding.

In the event that the liver is not palpable below the right costal margin, in the early stages of tricuspid insufficiency, the systolic pulsation of the right lobe of the liver may cause a distinct heaving of the ribs, which may be felt by placing a clenched fist against the lower ribs in the axillary region (Dressler, 1950).

The hepatic expansion of tricuspid insufficiency is only 17% sensitive (Cha and Gooch, 1983). First, it requires severe insufficiency in combination with a high right ventricular systolic pressure. Second, if the insufficiency is chronic, the patient may have developed cardiac cirrhosis, which inhibits the ability of the liver to expand.

Two important false positives are the Rosenbach sign of aortic insufficiency and presystolic A waves, which can be felt in the liver and misidentified as systolic (see Chapter 20).

The Murmur of Relative Tricuspid Stenosis

Once again, an increased amount of blood flowing over a normal valve produces the same type of sound as a normal amount of blood flowing across a valve of decreased area. This murmur of relative tricuspid stenosis is also augmented or elicited by hepatic pressure.

This sign confounds more often than it is diagnostically helpful, probably because cases of tricuspid insufficiency that regurgitate a sufficient amount of blood to produce the sign are easily diagnosed by other means.

The Paul Wood Winking Earlobe Sign

This really excellent sign was taught to me by Dr Dan Cabaniss of Alabama. The right earlobe blinks in time with the heartbeat because of retrograde cardiac ejection into the venous system (which also causes the venous distention of CV merger; see Chapter 19).

The winking earlobe sign may be present even in those patients in whom there is no apparent CV merger (Byrd, 1984) or in whom the external and internal jugular veins are themselves inapparent. Although its sensitivity is not 100% (it is more like 80% in chronic moderate tricuspid insufficiency), the finding is very dramatic when present.

False Positives

In conditions of high stroke volume, the earlobes can be moved by the arterial pulse pressure. The diagnostic difference is not only the company kept but also the following three characteristics:

1. With true positives, the right earlobe tends to be preferentially affected, probably because there is a straighter path from the right jugular vein down into the right ventricle. The carotid pulsations tend to shake both earlobes equally.
2. With false positives, only the part of the earlobe closest to the carotid artery shakes, whereas most or all of the earlobe winks with a true positive.
3. A true positive wink can be abolished by obliterating the jugular venous system from below, as by compressing the lateral neck without compressing the carotids, whereas this maneuver will not affect a cardioarterial shaking.

Heart Block

Very Advanced. It was possible to diagnose second-degree heart block correctly by carefully observing the regularly missing earlobe pulsation in a patient with tricuspid insufficiency.

Hepatojugular Reflux

The hepatojugular reflux was first described by Pasteur (1885) as being diagnostic (supposedly) for tricuspid insufficiency. Although it is a sensitive (66%) sign (Maisel et al., 1984) of tricuspid insufficiency, hepatojugular reflux (not reflex) is obviously not as diagnostic as Pasteur suggested. (See Chapter 19 for his entire article.)

Lateral Head Bobbing

This sign is discussed in Chapters 9 and 19.

A Difficult Differential

For the Attending. A patient with biventricular cardiomyopathy was admitted with a coarse, high-pitched, diamond-shaped murmur that radiated all the way to the left axilla, but not to the right midclavicle. Mitral insufficiency secondary to dilation of the left ventricle was diagnosed. After his ventricular failure was treated, others diagnosed tricuspid—not mitral—insufficiency. On reauscultation, the murmur was now only heard at the tricuspid area, and it no longer radiated to the axilla. No positive evidence for tricuspid insufficiency could be produced from the neck veins, the Vitums sign, the winking earlobe, and so on. Because of other problems related to his cardiomyopathy, he was eventually catheterized and found to have both tricuspid and mitral insufficiency.

This explicates how the absence of a large number of signs of high positive PV but imperfect sensitivity does not rule out a diagnosis. Note that a systolic murmur itself was of high sensitivity for each lesion, but of little value in distinguishing one from the other or from the concurrence of both. This also indicates that "inching" is not always effective in distinguishing two murmurs in the same time frame. Finally, this case illustrates the deficiency of Occam's razor.

Etiology

As with mitral insufficiency, tricuspid insufficiency can result from primary direct disease of the valve (as in infectious endocarditis or rheumatic valvulitis), or it can be secondary to dilation of the ventricle. If the signs wax and wane with increasing severity and with treatment of the ventricular problem, one may diagnose secondary tricuspid insufficiency.

However, one is often dependent on the case record for the results of past physical examinations. Thus, all examiners contributing to the care of the patient and the charting must be competent before one can use the appearance and disappearance of severe signs as evidence of secondary (versus primary) tricuspid insufficiency.

Tricuspid Stenosis

Clinical Signs

Clinically, tricuspid stenosis perfectly mimics mitral stenosis except in never developing secondary left atrial hypertrophy, right ventricular hypertrophy, and then pulmonary hypertension.

Conversely, tricuspid stenosis has four findings of its own that are lacking in isolated mitral stenosis: (a) giant A waves and impaired Y descent in the venous pulse (see Chapter 19); (b) inspiratory augmentation of the diastolic rumble in up to 80% of cases of tricuspid stenosis (Rothman and Goldberger, 1983)[18]; (c) the Kussmaul sign (see Chapter 19); and (d) a jugular or clavicular presystolic click (see Chapter 19).

False Positives

If mitral stenosis leads to severe pulmonary hypertension, then secondary tricuspid regurgitation can lead to relative tricuspid stenosis, hence giant A waves and a diastolic rumble that increases with inspiration despite an anatomically normal tricuspid valve. Fortunately, this is a very rare cause of false positives.

Pericardial Effusion[19]

Inspection

The best inspection clue is the absence of an observable PMI in situations in which, because of the very enlarged cardiac profile to percussion, one would be expected.

The Auenbrugger sign, an epicardial bulging due to massive pericardial effusion, is rarely seen these days. Why? (Write down your answers before turning to Appendix 17.8.)

Palpation

Similarly, a PMI may not be palpable at the apex of the percussed silhouette. Instead, it may be palpable inside the borders of cardiac dullness.

Percussion

Of course, a large effusion will cause an enlargement of the percussed silhouette. The Rotch sign refers to a lateral displacement of the right cardiac border. (Although some say with great confidence that this sign must be nonexistent due to the impossibility of percussing the right border of the heart, Dr Rotch would be surprised to hear this news, were he alive.)

Pericardial effusion can also be diagnosed from the obliteration of the cardiophrenic angles, as detected by percussion. A blunting of the angle on the right (the cardiac hepatic angle) is known as the Ebstein sign. Moschcowitz described a triad of signs that although individually inconclusive were together "thoroughly reliable as confirmed by roentgenogram examination or at autopsy" (Moschcowitz, 1933). These were (a) widening of the area of cardiac *flatness* to percussion; (b) widening of the area of cardiac *dullness* in the second intercostal space; and (c) an abrupt transition from pulmonary resonance to cardiac flatness. Moschcowitz noted that only the last had not yet been described in 1933.

The Dressler sign is a flat sound on percussing the lower half or two thirds of the sternum. In the absence of mitral stenosis, this finding "should at once arouse suspicion of pericardial effusion" (Dressler, 1950). Disregarding intermediate degrees of dullness and focusing his attention only on areas of absolutely flat percussion notes, percussion gave the correct diagnosis in 58% of Dressler cases, compared with only 13% for the chest film (Dressler, 1960).

Validating Percussion

Very Advanced. Dr H.B. Weiss reports on experiments done in the 1920s at the University of Cincinnati with Dr Roger Morris:

We sidetracked patients on the way to the morgue and passed them through the X-ray department. After careful percussion, we used lead strips on the patients' chests as markers [for the boundaries found by percussion] and made an AP film, following which we would start with an injection of 100 cc of ascitic fluid into the pericardial sac. We found that after injecting 250 cc there was a change in the cardiac silhouette principally at the mediastinum. This location may have been influenced by the fact that the cadaver was recumbent. Larger amounts of fluid produced more enlargement, including the body of the heart. [I do not remember that this was ever published.]

Signs of Consolidation (by Percussion and Auscultation)

Ewart described signs of consolidation of the left lower posterior lung fields due to massive pericardial effusion extending posteriorly.

Right posterior thorax signs of consolidation (the Conner sign) also occur in cases of pericardial effusion. In addition to dullness to percussion, the auscultatory signs of consolidation, such as tubular breathing, may be detected in the same area. Conner found posterior thoracic signs to be absent in only 18% of the pericardial effusions he studied, but in any patient who had the Ewart sign, right-sided findings were always present, although usually less extensive than those on the left (Conner, 1926).

An Ewart or Conner sign that disappears when the patient leans forward is the Bamberger sign of pericardial effusion.

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[18] It is not 100% since inspiration may decrease the murmur by increasing the distance between the sound point source and the stethoscope.

[19] For tamponade or constrictive pericarditis, see Table 19.2.

Auscultation

Although the softness of the heart sounds in cases of pericardial effusion has received a great deal of emphasis, this best known of the findings is of limited usefulness since (a) it does not occur with very small degrees of pericardial effusion; (b) even with large pericardial effusions detected by other techniques, this sign may be absent; and (c) false positives exist, for example, in many older patients or emphysematous patients. In cases of pericardial effusion, the presence of a rub tells you nothing about the volume of fluid present. However, it does tell you that the etiology is more likely to be viral, bacterial, postirradiation, or postmyocardial infarction (Markiewicz et al., 1980). Rubs are also heard in 25% of rheumatoid effusions, 14% to 83% of uremic effusions, but only 7% of neoplastic effusions (Markiewicz et al., 1980; Rutsky and Rostand, 1987). Rubs are usually not heard in effusions due to myxedema or congestive failure.

Other Tests

The ice water test is described in Chapter 28. Pulsus paradoxus (perhaps better called "pulsus exaggeratus," in Dr Atwood's view), a sign of tamponade, is discussed in Chapter 6. The loss of the Y descent in the cervical veins is described in Chapter 19.

When Is (Apparent) Congestive Heart Failure Not Congestive Heart Failure?

From the inclusion of this question at this point, the astute student may guess that one answer is when it is pericardial tamponade (see Chapter 19). Can you think of three others? Write your answers down before consulting Appendix 17.9.

Tamponade should be suspected in patients with hypotension and the following findings: elevated systemic venous pressure, falling blood pressure, pulsus paradoxus, tachycardia and dyspnea or tachypnea with clear lungs, chest or abdominal wounds, recent or concurrent evidence of pericarditis, and unexplained "cardiac" enlargement or evidence of pericardial effusion.

Apparent Combination Lesions

Murmur of Aortic Insufficiency Plus Murmur of Aortic Stenosis

The differential is between *relative* aortic stenosis in severe aortic insufficiency due to the large stroke volume and valvular aortic stenosis. This absolute aortic stenosis may be distinguished from relative aortic stenosis by the former's paradoxical splitting of S2, a slow rise of the carotid artery pulse wave, and a delay in time between the PMI at the apex and the peak carotid pulse rise (Chun and Dunn, 1982).

If other valves are involved, as in rheumatic heart disease, there is a greater statistical likelihood of structural aortic valvular stenosis. Conversely, if the aortic insufficiency is known to be luetic or is thought to be the result of aortic root disease (because the murmur radiates down the right side of the sternum), structural aortic valvular stenosis is unlikely from Occam's razor (i.e., there would have to be a second disease to explain the structural aortic valvular stenosis).

Murmur of Aortic Stenosis Plus Murmur of Mitral Insufficiency

This combination occurs with increasing frequency. In most of the situations to be described, there actually is a functional obstruction to aortic outflow, although the aortic valve itself is normal. There are five possible etiologies.

1. Idiopathic Hypertrophic Subaortic Stenosis

IHSS may cause changes in the anatomy and positioning of the papillary muscles so that there is poor coaptation of the mitral valve (Kramer et al., 1986).

2. Mitral Valve Prolapse

If the floppy valve leaflet is sufficiently flail, it may not only fail to coapt, but may even flutter back into the left ventricular outflow tract, producing a systolic murmur. The best way to detect a prolapsed mitral valve as a cause of this combination is to find a midsystolic click. Some workers have suggested that such prolapse can be diagnosed by changing the patient's position and noticing the murmur occupying earlier portions of systole. However, IHSS murmurs may become louder on standing and so seem to be "earlier." Alternately, to refute the hypothesis that a prolapsed mitral valve leaflet is responsible for an aortic outflow murmur, you could find evidence independent of the murmur for valvular aortic stenosis (e.g., delayed carotid upstroke, a paradoxically split S2, and prolonged apical–carotic impulse interval). A prolapsing mitral valve alone does not cause sufficient obstruction to produce such signs.

Note that in the above two cases, we have not suggested auscultating at Spodick's point (the right midclavicle) for amplification of the murmur of aortic stenosis because all forms of aortic stenosis discussed in this section will show such midclavicular amplification. However, Spodick's point can be used for refuting the existence of aortic stenosis in the next diagnosis.

3. Aortic Stenosis Mimicked by Mitral Insufficiency

When the systolic regurgitant jet squirts back into the left atrium and vibrates the aorta opposing the enlarged left atrium, the vibrations may be heard at the aortic root area as a diamond-shaped systolic murmur, as documented by intracardiac phonocardiography (Antman et al., 1978).

4. Gallavardin Phenomenon

See the discussion earlier in this chapter.

5. True Aortic Stenosis and True Mitral Insufficiency

Primary disease of both valves is most frequently seen in rheumatic heart disease. The best support for this diagnosis will be the finding of additional valvular lesions.

A Diastolic Decrescendo Murmur Accompanying Mitral Valve Disease

The differential diagnosis is between (rheumatic) aortic insufficiency and pulmonic insufficiency (see Steell's murmur). Features

that may help include the radiation of the murmur (Table 17.3) and the response to amyl nitrite (which often diminishes the murmurs of aortic insufficiency but not that of pulmonic insufficiency) or handgrip. A decrease in the intensity of the murmur with handgrip excludes aortic insufficiency.

A test of high diagnosticity but low sensitivity is to auscultate in the left axilla for the Cole–Cecil murmur, first described by Foster in 1874, and resurrected in 1908 (Cole and Cecil, 1908). If one can hear the diastolic decrescendo murmur there, one is listening to aortic insufficiency, not pulmonic insufficiency. (If one cannot hear the murmur in the axilla, no conclusion can be drawn.)

In differentiating the two murmurs, one should also search for the associated peripheral signs of aortic insufficiency, which are helpful only if the signs are present. Conversely, one should be cautious about diagnosing a Steell murmur unless there is physical evidence of right ventricular hypertrophy (such as a right ventricular tap).

Murmur of Aortic Insufficiency Plus Murmur of Mitral Stenosis

The Flint murmur is the murmur of rheumatic mitral stenosis where such does not exist. It is caused by relative mitral stenosis, the aortic regurgitant jet keeping the anterior mitral leaflet in a relatively closed position, obstructing diastolic filling of the left ventricle. The following discussion of the signs distinguishing the Flint murmur from the murmur of true mitral stenosis is summarized in Table 17.7.

First, look for the other signs of true mitral stenosis, which are not seen accompanying the Flint murmur. Of these, the opening snap, if present, is best. When present, a loud first heart sound also strongly favors true mitral stenosis. This is because the left atrial/left ventricular pressure gradient maintains the mitral valve leaflets in a relatively wide-open position until the beginning of ventricular systole, at which point they are slammed shut through a wide excursion. With the Flint murmur, the regurgitant jet holds the anterior leaflet of the mitral valve in a relatively closed position, reducing the excursion and reducing the normal intensity of the sound of mitral valve closure by about half. Furthermore, with the Flint murmur mechanism, there may be asynchrony to the closure of the two leaflets, also making the sound "mushy" or soft.

TABLE **17.7** *Differential diagnosis of Flint murmur versus true mitral stenosis combined with aortic insufficiency*

Finding	Mitral stenosis	Flint murmur
Opening snap	Maybe	Never
Loud S1	Often	Never
Increased P2	Often	Never
Diastolic thrill	Maybe	Never
High pitched	Rarely	Maybe
Apical presystolic wave	Only with mild mitral stenosis	Maybe
Effect on murmur of amyl nitrite	Usually louder (60%–82%) or no change	Often softer (86%)
Effect on murmur of pressor infusion	Usually not louder	Louder
Rhythm	Usually atrial fibrillation	Usually sinus
Duroziez murmur	Maybe lost	Maybe present
Hill sign	Maybe lost	Maybe present

Next, attend to the pitch of the mitral murmur. The Flint murmur tends to be higher pitched and the true mitral stenosis murmur more rumbling, although these features do not permit a perfect distinction. Occasionally, the murmur of mitral stenosis, if particularly severe, will take on a high pitch (J.E. Atwood, *personal communication*, 1998).

If you come upon that ancient instrument, the phonocardiograph, you may wish to use amyl nitrite and observe its effect upon the diastolic rumble. A decrease in the lower-pitched murmur with amyl nitrite supports the diagnosis of a Flint murmur. This is because the amyl nitrite decreases systemic vascular resistance (also called *afterload*), decreasing the amount of blood regurgitating back into the left ventricle in diastole, decreasing the degree of displacement of the anterior leaflet of the mitral valve in diastole, and so decreasing the murmur. But if the murmur gets louder, it suggests that the mitral rumble results from mitral stenosis.

By an opposite mechanism, infusion of a pressor agent causes the murmur of mitral stenosis to become softer or to remain unchanged. The Flint murmur may get louder or remain unchanged. The increased afterload increases the aortic/left ventricular diastolic gradient in aortic insufficiency, thus increasing the relative mitral stenosis that causes the Flint murmur. On the other hand, it tends to decrease the forward flow and possibly decrease the flow across the truly stenotic mitral valve. Squatting and isometric handgrip are two nonpharmacologic techniques producing the same distinctions.

A palpable presystolic wave at the apex would favor but not guarantee the diagnosis of a Flint murmur (Basta and Bettinger, 1979).

A final piece of evidence is based on the fact that aortic insufficiency patients with mitral stenosis tend to lose their Duroziez and Hill signs. Unfortunately, the Hill sign requires a hemodynamically significant degree of aortic insufficiency. Also, the reliability of the absence of the Duroziez murmur requires that the auscultator be good enough to detect it consistently when present. So these two findings tend to be helpful only when present, suggesting that the Flint murmur is the correct diagnosis.

Nonprecordial Murmurs

A number of systolic and diastolic precordial murmurs have been described in patients with massive pulmonary embolism, but these are lacking in specificity. More specific is the peripheral pulmonary murmur, with maximal intensity variously described in the subscapular, interscapular, subclavicular, and right anterior and axillary

or lateral areas of the chest wall. The murmurs may be continuous because of bronchial arterial collateral blood flow or continuous flow across a partially obstructing clot in the pulmonary artery.

Extracardiac nonprecordial murmurs have been reported in only a few other conditions. These include pulmonary arterial branch stenosis, mammary souffle (see Chapter 15), pulmonary arteriovenous fistula, coarctation of the aorta, arteriovenous fistula of the chest wall, bronchial collateral circulation, and high-volume shunts with a peripheral pulmonary arterial flow murmur secondary to atrial septal defects (Okada and Ewy, 1983).

A Comparison of Clinical Examination with Doppler Echocardiography

In the proper hands, Doppler echocardiography represents an epochal advance in the diagnosis of valvular heart disease. However, it has produced two problems. First, it can detect very minor lesions that do not produce audible murmurs. Second, it can detect "lesions" where there are none demonstrable by other techniques. Although echocardiographers are developing techniques for eliminating such false positives, the individual auscultator has no way of knowing—for any given patient—whether the reading is a true positive or a false positive. The potential extent of such false positives is shown in Table 17.8.

A note of caution concerning all new, sophisticated technology: The new methods may actually be so sensitive that they create a "disease" with lesser morbidity than its diagnosis and treatment. It remains to be seen whether a finding detectable only by Doppler has the same clinical significance as one producing an audible murmur (Fitzgerald, 1990).

Because the Doppler technique has shown the presence of some mitral regurgitation, and rarely aortic regurgitation, in otherwise healthy children, a finding on Doppler alone, without accompanying auscultatory abnormalities, is not adequate as the sole criterion for valvulitis in acute rheumatic fever (American Heart Association, 1992).

As the first edition of this work was being composed, continuous wave (and color) Doppler echocardiography appeared and swept all other imaging forms before it, especially for aortic stenosis. Still, there are a few points to remember before burning one's stethoscope.

1. Not all studies are technically satisfactory. Unsatisfactory studies occurred in 3% to 7.4% of reported series (Krafchek et al., 1985, Oh et al., 1988; Richards et al., 1986;Yeager et al., 1986). Even among those recordings rated as fair, satisfactory, or good the readers were, not surprisingly, more accurate with the good tracings than with the others (Currie et al., 1985).
2. Experienced readers are more accurate than less experienced readers (Currie et al., 1985; Panidis et al., 1986). Error is most likely when the junior reader misidentifies the gain setting, but such errors do not appear in the journals.
3. Moderate-to-severe concomitant aortic insufficiency decreases accuracy; so does atrial fibrillation (Panidis et al., 1986).
4. The pressure gradient does not always reflect the severity of the aortic stenosis. In a setting of low cardiac output, the amount of blood flowing through the valve is reduced, and the gradient is reduced concomitantly. The ultimate answer is not the pressure gradient, but the valve area, which is calculated from the continuity equation, which is imperfect. The area thus calculated may differ from the area obtained at cardiac catheterization by a different method; the Doppler method may be more accurate (Feigenbaum, 1994). As cardiologists have gained increasing confidence in this technique, some no longer cross stenotic valves at cardiac catheterization but rely on the areas calculated from the Doppler (J.E. Atwood, *personal communication*, 1998).

TABLE **17.8** *False-positive rates for Doppler echocardiography in some reports*

Lesion and reference	Percentage
Aortic stenosis	
Krafchek et al. (1985)	18
Nitta et al. (1988)	12
Aortic insufficiency	
Kostucki et al. (1985)	32
Mitral insufficiency	
Kostucki et al. (1985)	36
Pulmonic insufficiency	
Yock et al. (1984)	40
Takao et al. (1985)	78
Kostucki et al. (1985)	92
Tricuspid insufficiency	
Jacksch et al. (1985)	21
Kostucki et al. (1985)	44
Yock et al. (1984)	96

Echocardiography and Cardiac Function

Echocardiography is used more often to assess cardiac function than to evaluate heart murmurs as congestive heart failure is the leading cause of cardiac morbidity and mortality in the US. Doppler techniques are the clinical standard for assessing left ventricular diastolic dysfunction, which is underappreciated although it is, in isolation, the cause of about one third of the cases of congestive heart failure. This portable, safe technology can rapidly rule out other causes of heart failure, such as valvular disease, pericardial disease, or systolic dysfunction (Naqvi, 2003).

Conclusions

Some workers believe that all auscultatory findings must be confirmed by Doppler. Although this is fine for positive findings, it will not be practical for negative findings until every physician has a color-Doppler-echocardiograph-cum-technician in his little black bag.

Like all technologic aids, echocardiography can be used in a highly ineffective way. The following errors are made all too often:

1. Providing the consultant with insufficient clinical information
2. Making the consultant guess what you are looking for

3. Failing to understand the limitations of the technology, particularly when you are substituting it for your own skills
4. Interpreting the absence of evidence as evidence of absence
5. Forgetting the basic law of consultation exemplified in the following story:

Many years ago, there was an actor on the Yiddish stage named Boris Tomashevsky. One night as he was removing his makeup after a performance, a beautiful young woman appeared at his dressing room door to tell him how wonderful he was. He listened and spoke, and one thing led to another.

The next morning he let her out of his dressing room, expecting never to see her again, but the following night she again appeared, this time with a baby in her arms and demanding money, which he refused. "But you don't understand, Mr Tomashevsky," she said. "I am a young widow. My husband died and left me with nothing but this baby whom I must support. My baby must have bread."

"I am Tomashevsky, the Actor," he replied in his most stentorian tones. "If it's bread you want, you should go to Tomashevsky the Baker."

Moral: What you get depends on whom you ask.

A Note on Cardiopulmonary Resuscitation

If a person has a cardiac arrest (not a respiratory arrest), the worst thing you can do is to delay chest compressions or to interrupt them for any reason other than to defibrillate. You must, of course, summon help because a patient who has no pulse will die unless he can be defibrillated. But do not delay chest compressions while the defibrillator is being set up or a mask is being looked for, as the seconds without perfusion jeopardize the heart and the brain and reduce the probability of a successful outcome.

The standard procedure for cardiopulmonary resuscitation (CPR) has been to initiate with mouth-to-mouth or mouth-to-mask ventilation and, in single-rescuer CPR, to give two "quick breaths" between each 15 compressions, thus interrupting perfusion for about 15 to 16 seconds. This procedure, established in 1966 and reaffirmed in 2000 by the Ad Hoc Committee on Cardiopulmonary Resuscitation of the Division of Medical Sciences, National Academy of Sciences—National Research Council, has been criticized for a number of reasons (Ewy, 2003).

Because of concerns, warranted or not, about acquiring an infectious disease, the frequency of bystander CPR has decreased. Even instructors in basic life support (BLS) and physicians and nurses might withhold or hesitate to perform mouth-to-mouth resuscitation on an adult stranger (Berg et al., 1995; Locke et al., 1995). Moreover, it is a complex skill, and only 33% of laypersons could perform BLS appropriately on a mannequin immediately after completing the course, and only 11% 6 months later.

Studies on swine have demonstrated that the use of chest compressions alone, even with a totally occluded airway (Kern et al., 1998), has outcomes just as good as standard CPR following 6.5 minutes of cardiac arrest. During the first 10 to 15 minutes after witnessed cardiac death, critical limits for pH and oxygen saturation are not commonly breached during BLS, with or without mouth-to-mouth breathing. In a swine study that compared continuous chest compressions to standard CPR with realistic interruptions for ventilation, the former group had significantly better coronary perfusion and neurologically normal 24-hour survival. Defibrillation was attempted in this study after 15 minutes (Kern et al., 2002). After 4 minutes of chest compression alone, a group of swine receiving a compression:ventilation ratio of 100:2 had a significantly better outcome than those receiving the standard 15:2 ratio (Sanders et al., 2002).

Ewy and co-workers at the Sarver Heart Center of the University of Arizona (Berg et al., 1993; Ewy, 2005) believe that the sequence for single-rescuer CPR in patients who have not had a primary respiratory arrest should not be ABC (airway, breathing, circulation), but AC-B (opening the airway by proper head and neck positioning, circulation, and—much later—breathing). A study of 3,045 out-of-hospital cardiac arrests in Belgium (Bossaert et al., 1989; Van Hoeyweghen et al., 1993) showed results consistent with those of studies in swine (Berg et al., 1995): "Good quality" standard CPR was much better than no bystander CPR but had no demonstrable advantage over "good quality" external chest compressions alone.

Those who wish to base their practice on actual field experience and experimental work with sophisticated physiologic monitoring, rather than recommendations of committees, should review this literature.

Physicians who did this work learned from a layperson and an unconscious patient: "Why is it every time I press on his chest he opens his eyes, and every time I stop to breathe for him he goes back to sleep?" asked an anonymous bystander during a telephone-directed CPR (Berg et al., 1993).

By 2008, this work was incorporated into official American Heart Association recommendations (Sayre et al., 2008).

More Advanced Imaging

Instead of a recital of risk factors, which a patient with coronary artery disease might or might not have, physicians of the future might proceed directly to noninvasive imaging of the coronary arteries. One screening method looks for calcification in the coronary arteries. Another uses an ultrafast, cine-computed tomographic scanner that can distinguish blood circulating in the coronaries in contrast with pericardial fat. Significant coronary occlusions were found by this method in 32 (22%) of 147 asymptomatic patients, in whom this study was the first evidence of coronary disease (Coin, 1993).

Appendix 17.1

Massive Pericardial Effusion and the PMI

Why do patients with a massive pericardial effusion usually not have a visible PMI? With a massive pericardial effusion, the heart swings and contracts inside a bag of fluid that keeps it from striking the chest wall and making the PMI. This is the same reason that you do not bump the floor when you sit on a water bed.

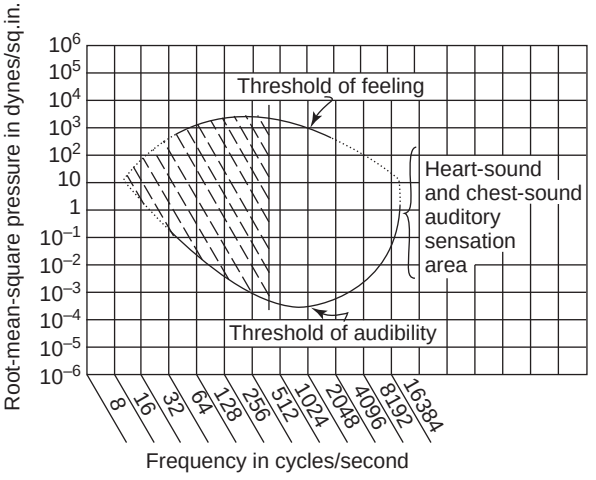

FIGURE 17-15 Average normal threshold curves of audibility and feeling. (From Rappaport MB, Sprague HB. Physiologic and physical laws that govern auscultation. *Am Heart J.* 1941;21:258–318, with permission.)

Appendix 17.2

Answer to Self-study on Page 323

See "Locating the Apex" section. The PV of a negative test is about 91%, and the PV of a positive test is about 31%. Thus, percussion is a reliable way to exclude an increase in LVEDV or LVM, but not a good way to diagnose it.

Appendix 17.3

Why Laënnec Could Hear Better Than He Could Palpate

Laënnec could hear what he could not palpate because the threshold of hearing is lower than that for feeling, except at extremely low frequencies (Fig. 17-15).

Appendix 17.4

Key to Fig. 17-11

In Fig. 17-11, the left column is IHSS and the right is valvular aortic stenosis. The bottom row represents volume depletion (or standing up). Now, can you draw the intensity of the murmur under each condition?

Appendix 17.5

Differential Diagnosis of a Murmur

The exclusions were based on the dimensions of location, radiation, and intensity; therefore, the reasoning is the same.

Appendix 17.6

Self-test on Mitral Valve Prolapse

1. The positive PV of a murmur = true positive (TP)/[TP + false positive (FP)]. The number of persons with mitral valve prolapse was 208, and of these, 9% or 19 had a murmur (TP = 19). Of the 2,717 persons without mitral valve prolapse, 3.53% or 96 had a murmur (FP = 96). Therefore, the positive PV = 16.5%.
2. The PV of a negative test = true negative (TN)/[TN + false negative (FN)]. The number of true negatives is (2,717 − 96) or 2,621, and the number of false negatives is (208 − 19) or 189. Hence, the PV of a negative test is 93%.

Appendix 17.7

CPC Diagnosis: A Case in Which a Murmur Similar to That of Mitral Stenosis Was Not Mitral Stenosis

Dr Thomas Dorman of Kent, Washington, referred the patient for an immediate echocardiogram, asking the sonographer to look for an atrial myxoma. A large left atrial myxoma was found and successfully removed. Dr Dorman made the following comments: mitral stenosis develops gradually, whereas an atrial myxoma may grow quite rapidly. It is rare for a person with advanced mitral stenosis to be in sinus rhythm; atrial fibrillation is usual. The murmur did not have the classic mitral complex with opening snap, presystolic accentuation, and loud S1. This author also notes that a computerized medical record in standard format would have been of no value to this patient and in the hands of a third-party payer might have caused her great harm. The diagnosis, which imminently threatened the patient's life, was made by a physician who interviewed the patient and performed a physical examination first hand.

Appendix 17.8

The Auenbrugger Sign

The Auenbrugger sign is rarely seen these days because: (a) it is rarely sought, (b) our patients have more fat than Auenbrugger's did, (c) effusion is diagnosed much earlier because of echocardiography, and (d) Auenbrugger's patients lived prior to pericardiocentesis.

Appendix 17.9

When is Congestive Heart Failure Not Congestive Heart Failure?

The answer is when it is constrictive pericarditis, inferior vena cava thrombosis, or tricuspid stenosis.

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CHAPTER

18

Arteries

How should it happen that, if you tie the arteries, immediately the parts not only become torpid, and frigid, and look pale, but at length cease even to be nourished?

—William Harvey, *On the Motion of the Heart and Blood in Animals,* 1628

Points to Remember:

- In a case of suspected arterial vascular disease, the worst thing you can do is fail to measure the blood pressure in all four extremities.
- It is possible to produce a bruit in any vessel by exerting sufficient pressure with a stethoscope.
- Listen for carotid bruits as a sign of vascular disease. Further evaluation of a bruit may be advisable depending on symptoms, other findings, and the availability of safe interventions.
- Always think of temporal arteritis in a person over the age of 50 with persistent unexplained pain above the neck.
- An ankle–brachial systolic pressure index (ABI) less than 0.5 is limb threatening, even in the presence of palpable pedal pulses.
- Palpation, auscultation, and the special maneuver of taking the blood pressure are all oriented to the same purpose: determining occlusion and flow. Therefore, this chapter is organized by region (or by specific vessel) rather than in the usual manner by method of investigation.

There are four points to remember in examining the arteries.

1. In patients with atrial fibrillation or any other condition producing wide beat-to-beat variation in stroke volume, it is a good idea to palpate the arterial pulse on both sides at the same time. Thus, the relative strength of each side during the same stroke volume can be compared. Otherwise, one runs the risk of missing all but the most blatant degrees of decrease in arterial pulsation, especially as the arterial pressure is less useful (Chapter 6). (This is also a good general rule of examination even if the patient is not in atrial fibrillation.)
2. A bruit can be consistently produced over any vessel if one compresses it sufficiently with the stethoscope. (This misadventure is most likely to visit those who are not aware of the possibility of its occurring.)
3. *Meador's Rule*[1]: The worst thing you can do in a case of suspected arterial vascular disease is to fail to measure the blood pressures in all appropriate portions of the extremities. This may seem self-evident but needs to be emphasized to the neophyte who believes that simple palpation will often suffice. Such neophytes should note that peripheral vascular surgeons with years of experience do not rely on palpation but quantitate their observations with pressure measurements, often with the use of a Doppler, even though their diagnostic acumen may be the equal of the laboratory's.
4. Patients with palpably normal pulses may still have arterial insufficiency, as may be demonstrated by the special maneuvers described in this chapter.

Carotid (and Vertebral) Arteries

Inspection

One branch of the internal carotid artery is accessible to direct inspection in the fundus. The plaque of Hollenhorst is a sign of an ulcerated atheromatous plaque in the ipsilateral carotid system (see Chapter 10).

Palpation: Pulse Wave Contour

The carotid artery is most easily found by placing your index and third fingers on the thyroid cartilage and slipping them laterally between the trachea and the sternocleidomastoid. Palpate gently and low in the neck to avoid the carotid sinus.

Although all arteries have a recordable pulse wave contour, the carotid artery is the best artery for detecting it in terms of cardiac assessment.

Examine Fig. 18-1 and see whether you can tell the significance of each of the tracings. Then read on. Tracing A is a normal one for comparison.

Pulsus Parvus et Tardus[2]

Pulsus parvus et tardus is a sign of aortic stenosis (see Chapter 17) and may also be called the *anacrotic pulse* because of the anacrotic notch, indicated on the pulse wave contour (Fig. 18-1B) by the arrow. I can almost never feel the notch. Also, the exact rate of rise of the carotid upstroke is poorly estimated by clinical examination (Spodick et al., 1982). However, in cases of *severe* aortic stenosis, the upstroke is so delayed that one can learn to detect it at the bedside.

False Positives

Carotid upstroke may also be measurably decreased because of any left ventricular outflow obstruction (e.g., idiopathic hypertrophic subaortic stenosis [IHSS]), any significant vascular obstruction

[1] Named for Dr Cliff Meador, a Tennessee endocrinologist. When he was the dean at the University of Alabama, he had the habit of asking, "What is the worst thing I could do here?" when others might have asked, "What is the best way of doing this?" This question initially seemed peculiar, but I later realized that it showed great insight.

[2] "Small and slow-rising." This phrase does *not* mean bradycardia.

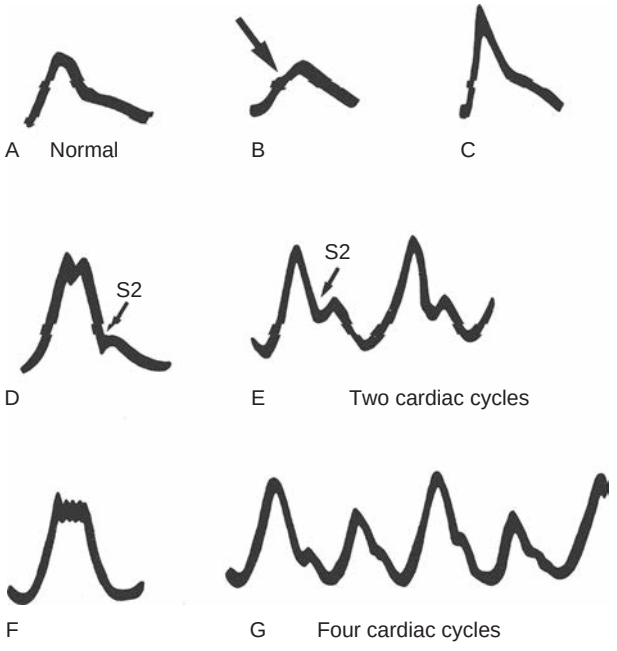

FIGURE 18-1 Carotid pulse wave contours. See text.

(e.g., atheroma between the left ventricle and the carotid artery), or any decrease in forward stroke volume (e.g., congestive heart failure, mitral insufficiency, or ventricular septal defect with a left-to-right shunt).

False Negatives

Unfortunately, carotid upstroke increases in the aged because of the changed compliance of their atherosclerotic vessels. Thus, in the elderly, the decreased carotid upstroke of aortic stenosis plus the increased upstroke due to age may yield an upstroke that seems to be within the range of normal values, albeit for a younger population (Flohr et al., 1981). This is not an artifact due to unskilled palpation but can be demonstrated with external carotid pulse tracings.

Corrigan Pulse

The Corrigan, or Watson water hammer, pulse (Fig. 18-1C) was first described by de Vieussens. One hundred years later, Corrigan and Hope, Irish clinicians, noted that many patients with aortic insufficiency had a de Vieussens pulse. Later still, Watson described the pulse as feeling like a water hammer, a Victorian child's toy. This pulse can also be easily detected at the radial artery.

A Teaching Trick

To make a water hammer, take a piece of thin-walled glass laboratory tubing and seal one end in a Bunsen burner. Add water about one third of the way up. Heat the open end so that you will be able to close it quickly, then boil the water to produce steam while the open end is still workable.

As the steam flows out the hot end of the tubing, seal it off quickly. Permit the tube to cool for a few minutes. After the steam condenses, the tube will contain water under a vacuum.

Holding the tube in your hand, turn it so that the water is at the top. The sensation caused by the water falling through the vacuum is what Watson felt in his patients' pulses.

False Positives

Like many of the old signs of aortic insufficiency, the Watson water hammer pulse is actually a sign of wide pulse pressure and/or a high stroke volume being ejected down a relatively lax vascular tree. Thus, any *condition* marked by high stroke volume/high flow/wide pulse pressure has been found to produce a water hammer pulse.

Additionally, mitral insufficiency may rarely have a Corrigan pulse.

False Negatives

Mild cases of aortic insufficiency have insufficient flow to cause a water hammer pulse.

Bisferiens Pulse

The first type of bisferiens pulse (a pulse with two systolic peaks, shown in Fig. 18-1D) is supposedly sensitive for the diagnosis of IHSS. However, it has been found in combined aortic stenosis and insufficiency (Wood, 1956). In aortic stenosis, it seems to indicate a good cardiac reserve (McAlpin and Kattus, 1965).

The other type of bisferiens pulse (Fig. 18-1E), also called a *dicrotic pulse*, was initially described in febrile patients, especially in those with typhoid fever, and attributed to "arterial relaxation." Recently, however, it has been described in young patients with elevated peripheral resistance and low stroke volume. Disease states have included primary myocardial disease, hypertensive cardiovascular disease, ischemic heart disease, primary pulmonary hypertension, and pericardial tamponade. In afebrile patients at rest, a marked dicrotic pulse may be a sign of severe functional impairment of the myocardium. Early case descriptions may have been of patients who had typhoid myocarditis or a low stroke volume secondary to severe dehydration from diarrhea (Ewy et al., 1969).

Auscultatory evidence of pulsus bisferiens may be sought as follows (McAlpin and Kattus, 1965). While auscultating over the brachial artery, gradually increase the pressure of the stethoscope bell, using the edge closest to the heart to indent the brachial artery. Eventually, one will hear the usual indentation systolic bruit, which, in cases of pulsus bisferiens will—at a critical pressure somewhere below systolic—split into two short bruits.

This technique detected bisferiens pulses that were otherwise detectable only by utilizing graphic recordings of the pulse wave.

Carotid Shudder

Evidence for a peculiar systolic tactile phenomenon called a *carotid shudder* was first presented in 1945 (Evans and Lewes, 1945). At the time, the sign was believed to occur only in conjoined aortic stenosis and aortic incompetence and not in either lesion in the absence of the other. The carotid artery tracings (Fig. 18-1F) showed that the systolic peak was replaced by a number of rough undulations, which apparently produced the tactile sensation of "shuddering" or "shivering." Dr Eugene D. Robin of California also taught a variation of this sign in which the systolic undulations were so fine that the tactile sensation was more like a cat purring. Whereas coarse shudders are invariably palpable, fine shudders are at times felt and at other times not perceived (Alpert et al., 1976).

This sign is useful but insensitive (i.e., most patients with combined aortic insufficiency and stenosis do not have it). Furthermore, the carotid shudder may be less diagnostic than originally thought

TABLE **18.1** *Incidence of carotid shudders in patients with proven aortic valve disease*

Patient group	Coarse shudder present (%)	Fine shudder present (%)
Aortic stenosis only ($n = 30$)	50	17
Aortic insufficiency only ($n = 29$)	24	24
Combined aortic stenosis and insufficiency ($n = 14$)	43	14

From Alpert JS, Vieweg WVR, Hagan AD. Incidence and morphology of carotid shudders in aortic valve disease. *Am Heart J*. 1976;92:435–440, with permission.

(Table 18.1). In a study of carotid pulse tracings of 73 patients with advanced aortic disease documented by cardiac catheterization, neither the fine nor coarse undulations had any significance other than indicating the presence of aortic valve disease, being found in isolated stenosis or insufficiency as well as in combined lesions (Alpert et al., 1976).

The carotid shudder does not guarantee the presence of a major lesion. I have detected this sign in patients with no aortic regurgitation and no aortic valve systolic gradient at cardiac catheterization. Others had no significant stenosis as judged by the Doppler velocity display. All had calcification of the aortic ring and the aortic valve as demonstrated by echocardiogram.

Other false positives result from carotid obstruction and kinking.

Palpation: Inequalities of Carotid Pulsations

Pulsus Alternans (Inequality Across Time)

Figure 18-1G does not represent bigeminy because the beats occur at perfectly regular intervals.

Pulsus alternans is an important sign of myocardial failure caused either by a primary myocardial problem or by an overwhelming challenge to the myocardium, for example, from a greatly increased peripheral vascular resistance. It may also occur during tachycardia.

Inequality Between Sides

A weakened carotid pulse on one side probably signifies ipsilateral occlusion of the common carotid. Other causes of unequal carotid pulsations are aortic aneurysm, double aortic arch, atypical coarctation, and cervical rib syndromes (Silverstein et al., 1960b). However, if the carotid and the superficial temporal pulses are both missing only on one side, then there is probably ipsilateral occlusion of the common carotid (Silverstein et al., 1960b).

Auscultation (Including the Vertebral Arteries) for Neck Bruits[3]

A Method

Listen over the carotid artery high in the neck and inch downward toward the precordium in order to help distinguish a carotid bruit from a transmitted heart murmur. Be sure to listen with the bell of the stethoscope over the bifurcation of the common carotid at the level of the upper border of the thyroid cartilage (Gilroy and Meyer, 1962). Also, listen in the subclavian fossa just posterior to the sternocleidomastoid, immediately above its clavicular origin, and over the posterior neck. (Remember that the subclavian artery is the origin of the vertebral artery.)

Bruits at the top of the neck are thought to be more important than those at the base that do not radiate, especially if the latter can be altered by subclavian compression (David et al., 1973; Ziegler et al., 1971). It has also been said that an important bruit is one that is high pitched or loud (Duncan et al., 1975). However, agreement of physicians on the intensity, pitch, or duration of a bruit is only fair ($\kappa < 0.4$), whereas agreement on the presence or location of the bruit is substantial ($\kappa = 0.67$) (Chambers and Norris, 1985).

Carotid Compression

Owing to increased flow, a carotid bruit may be intensified by compression of the contralateral artery. However, carotid compression should not be used as a routine diagnostic maneuver for carotid occlusion, especially in older patients, because it has caused serious complications such as hemiplegia (Silverstein et al., 1960a,b) and even death (Webster et al., 1955). Precautions are described in Chapter 9 and in the discussion of special maneuvers (*vide infra*).

Continuous Neck Bruits

A continuous murmur over a partially obstructed artery indicates that the gradient continues to exist in both systole and diastole. This situation is found with high-grade stenosis. There are many conditions that produce a false positive (Table 18.2).

Auscultating for Heart Sounds in the Neck

Suppression of the heart sounds over the carotids on turning the head (Gilroy and Meyer, 1962) and softness of the heart sounds (determined both clinically or by phonocardiographic display) have been advocated as signs of obstructive disease of the carotids (Kartchner and McRae, 1969).

Factors Affecting the Intensity of Murmurs

The variables that affect the intensity of bruits, both over the carotids and over other arteries, include the distance between the

[3] "Bruit" is French for noise and is used in English as synonymous with murmur.

TABLE **18.2** *Continuous carotid bruits as a sign of carotid stenosis (including evocation by contralateral carotid compression)*

Prevalence (Berry, 1965; Crevasse and Logue, 1958)	False positives (Allen, 1965) (% of cases with continuous murmur that had this diagnosis if known)
1% of hospitalized patients 1% of nursing home patients	Aortic arch syndrome (Myers et al., 1956) Severe anemia and fever (8) (Allen and Mustian, 1962) Meningioma Glomus jugulare tumor Thyrotoxicosis Paget disease Normal people (!) Carotid-cavernous sinus fistula or intracranial angioma (13) (Allen and Mustian, 1962) Contralateral occlusive disease

Note: Although these authors wrote of "continuous murmurs" in practice, some of them are simply systolic murmurs with a diastolic murmur added and thus are "continuing" murmurs and not truly "continuous" as defined in the text.

stethoscope and the occlusion (the intensity of sound diminishes according to the inverse square law), the velocity of blood flow, the density of the blood, and the size of the stenotic orifice.

False Negatives

The absence of a bruit is not so helpful because there may be total occlusion of the vessel (Matthews, 1961). Also, some significant lesions do not produce a bruit.

False Positives

With carotid vessels, as with others, a systolic bruit can be produced in a completely normal vessel merely by pressing hard enough to indent the vessel with the stethoscope, thus causing stenosis with turbulence. In fact, failure to produce a murmur under such circumstances could be considered as evidence that the vessel is thrombosed.

Other conditions that produce noises in the neck include venous hums (see Chapter 19) and transmitted heart murmurs (see Chapter 17). The murmur of valvular aortic stenosis is usually transmitted into the carotid arteries. While it decreases in intensity as it is transmitted up the neck, this murmur may be louder in the neck than it is at the second intercostal space near the sternum. Also, the murmurs due to the ruptured chordae tendineae of the mitral valve and the systolic ejection murmur due to severe aortic regurgitation may be heard in the neck (Hurst et al., 1980).

A supraclavicular bruit, common in children but also heard in adults, may result from increased arterial flow or the velocity of left ventricular ejection (Hurst et al., 1980).

Carotid Disease and Stroke

The main reason for auscultating for cervical carotid bruits in symptomatic patients is to look for a surgically correctable lesion. Numerous studies, using different methods, have reported widely varying results for the diagnosticity of carotid and subclavian bruits.

Symptomatic Patients

In symptomatic patients, the likelihood ratio (LR) for high-grade carotid stenosis was found, in two studies, to be 1.6 or 3.2 when bruits were present and 0.6 or 0.3 when bruits were absent (Sauvé et al., 1993).

Symptomatic means having transient ischemic attacks (TIAs), in which strokelike symptoms last only for minutes to hours. The classic TIA due to atherosclerotic lesions of the common or the internal carotid is amaurosis fugax. One may be able to see the causative embolus—the plaque of Hollenhorst—on retinal examination.

Characteristically, patients report a black or dark shade spreading across the visual field of the affected eye and disappearing after a few minutes. Less commonly, in severe carotid stenosis, transient visual loss due to hypoperfusion occurs under circumstances that increase retinal oxygen demand (such as exposure to bright light) or decrease perfusion pressure (such as postural change). In very rare circumstances, it occurs postprandially when splanchnic blood flow is increased at the expense of other regions. Patients report scotomata in a blotchy pattern, as if "mud had been thrown over the bathroom walls," lasting minutes to hours (Levin and Mootha, 1997).

Patients with "dizziness," generalized subjective weakness, "blurry vision," syncope or near syncope, or transient positive visual phenomena such as "floaters" are not considered to be symptomatic for possible carotid stenosis (Lanzino et al., 2009).

Focal carotid bruits (those heard only over a well-localized region of the bifurcation of the artery in the region of the upper border of the thyroid cartilage) had the best correlation with high-grade stenosis in one study, increasing in frequency with increasing degrees of stenosis, peaking in the 70% to 89% range and becoming less common as the stenosis exceeded 90% (Sauvé et al., 1994). Others found that a focal bruit was no more accurate than a diffuse bruit in predicting moderate-to-severe stenosis in the ipsilateral carotid (Ingall et al., 1989).

Asymptomatic Patients

An asymptomatic carotid bruit not caused by stethoscope indentation may be a marker for increased risk of stroke, either ipsilateral or contralateral to the bruit. There is skepticism on that score (Bergan et al., 1984), and it is important to remember that only about 50% of asymptomatic patients with carotid bruits have detectable carotid stenosis (Donaldson et al., 1987). In a cohort of 4,442 persons without a history of stroke or myocardial infarction, who were participating in the Systolic Hypertension in the Elderly Program, the incidence of stroke over a mean follow-up period of 4.2 years was 7.4% in those with carotid bruits and 5.0% in those without. The association was confounded by more important stroke risk factors, and in enrollees aged 70 years or more, there was no relation between a carotid bruit and a later stroke. Authors of the study concluded that their results "confirm the accepted notion that carotid bruits are a sign of generalized atherosclerosis, rather than a useful marker of clinically significant carotid artery disease" (Shorr et al., 1998). Thus, patients with bruits need a particularly careful examination for coronary artery disease, aortic aneurysm, or peripheral vascular disease (Hurst et al., 1980). Another study showed that patients with asymptomatic cervical bruits had a 3.4-fold higher risk of dying of ischemic heart disease (Heyman et al., 1980). However, a 5-year prospective study showed that the average annual stroke rate was three times as high (1.5%) in patients with bruits compared to those without bruits (0.5%) (Wiebers et al., 1990). A prospective study of patients with type 2 diabetes showed that patients with an incidental carotid bruit had a greater than sixfold higher incidence of stroke within 2 years than patients without a bruit (Gillett et al., 2003).

Carotid Duplex Scanning

Carotid duplex scanning is a considerably more accurate tool for detecting asymptomatic disease than is auscultation for bruits, with a reported sensitivity of 96% and a specificity of 85% for detecting a stenosis of greater than 70% (Rockman et al., 1997). Others note that carotid ultrasonography results are highly user dependent, with sensitivities for severe stenosis ranging from 72% to 97% and specificities ranging from 83% to 95% (Whitty et al., 1998). If the physician performs the test himself, he can obtain as many views as he needs to be certain of the results. Owing to Medicare cuts in allowed fees, the performance of the test is generally delegated to technologists these days and the interpreting physician is totally dependent on the data presented. Correlation of duplex scanning results with angiography results within each institution is recommended (Chang et al., 1995).

The recent addition of color to carotid duplex has improved the ability to distinguish between high-grade stenosis and occlusion.

What If the Results Are Positive?

The key question is whether patients should be referred for surgery if disease is found. Definitive answers are elusive for a number of reasons. One is the difficulty in conducting studies. In a population with a low ipsilateral stroke rate (2.5% annually), more than 3,000 patients would have to be studied to demonstrate a 50% reduction in the stroke rate in the surgical group (Wittgen and Brewster, 1997). Moreover, surgical outcomes are quite dependent upon the skill and experience of the surgeon and the preoperative state of the patient. In a review of the records of 6,038 patients who underwent carotid endarterectomy in Ontario in the period 1994 to 1997, the 30-day postoperative stroke or death rate was as high as 16% in patients with several risk factors. The risk factors included history of a prior TIA or stroke, atrial fibrillation, contralateral carotid occlusion, congestive heart failure, and diabetes mellitus (Tu et al., 2003).

Use of the duplex scan as a screening tool was stimulated by the results of the Asymptomatic Carotid Atherosclerosis Study, which showed a 53% reduction in the aggregate 5-year risk of ipsilateral stroke combined with any perioperative stroke or death in surgically treated patients (who also received medical treatment). The rate in surgically treated patients was 5.1% versus 11% in patients treated only with daily aspirin and risk-reduction measures (Executive Committee for the Asymptomatic Carotid Atherosclerosis Study, 1995). These results look less impressive when one considers that the probability of *not* having a stroke if surgery is deferred is 89% at 5 years (Rockman et al., 1997) or that surgery possibly prevents only one stroke per 100 persons per year. In contrast, only 8 symptomatic patients with high-grade (>70%) stenosis needed to be treated with carotid endarterectomy to prevent one stroke in a 2-year period (Barnett et al., 1998). Much of the benefit is lost if surgery is delayed more than 2 to 4 weeks after the symptomatic event (Lanzino et al., 2009).

As in screening for other conditions, the prevalence of disease in the population is extremely important. If the prevalence of carotid stenosis is that of the general population, less than 1%, then screening causes more strokes than it prevents. Only in populations with a prevalence of disease greater than 20%, as well as in centers with the best angiographic and surgical results, are significant benefits seen (Whitty et al., 1998).

The prevalence of disease is higher in patients seen by vascular surgeons. In a cohort of veterans, the presence of smoking, cardiac disease, or peripheral vascular disease was associated with an increased risk of greater-than-50% carotid stenosis. The prevalence rate among veterans with all three risk factors was nearly 18% (Fowl et al., 1991). In another study, nearly 25% of patients with claudication had carotid stenosis greater than 50% as was determined on duplex examination. This study also found that a low ankle–brachial systolic pressure index (ABI) (see Chapter 6) is highly predictive of carotid stenosis (Marek et al., 1996).

Of patients presenting with ophthalmologic findings of vascular disease (see Chapter 10), 70% were shown to have stenosis of the carotid artery greater than 50%. The findings included asymmetric hypertensive retinopathy, central or branch retinal artery occlusion, retinal plaques, venous stasis retinopathy, or ischemic optic neuropathy (Lawrence and Oderich, 2002).

The availability of less invasive therapy, namely carotid angioplasty and stenting, might change the risk: benefit analysis, but relative safety and efficacy compared with endarterectomy are not resolved as of 2009 (Lanzino et al., 2009).

Embolic Stroke

Because of its surgical implications, much attention has been focused on carotid artery disease, yet only about 22% of strokes can be clearly attributed to this cause. An embolus that causes a

stroke could come from a source other than an ulcerated carotid plaque. At least 15% of strokes (and probably many more) are the consequence of cardiac disease, including atrial fibrillation, ventricular aneurysm, or dilated cardiomyopathy. Another possibility is paradoxical embolization through a patent foramen ovale, which may be detected only by transesophageal echocardiography (Zhu and Norris, 1990) or transcranial Doppler ultrasonogram following the peripheral injection of microbubbles (see Chapter 17). Neurologists too must examine the heart and be aware of advanced cardiac imaging methods.

Conclusions

More aggressive screening for carotid disease may be warranted if better treatments become available. Better still, a large portion of this chapter could be made obsolete by more effective treatments for generalized atherosclerosis. On the basis of barely discernible differences in local manifestations of a systemic disease, a vast and expensive effort has been made to optimize the use of an invasive procedure with significant risk and limited potential. In the meantime, this author makes the following recommendations:

1. Listen for carotid bruits as part of the general cardiovascular examination.
2. Obtain carotid duplex ultrasonography on patients with symptoms referable to the anterior cerebral circulation, whether they have a bruit or not.
3. If an asymptomatic patient has a bruit or undergoes a change in a previously heard bruit or is at high risk for a carotid stenosis, carotid duplex ultrasonography is indicated.
4. Do not focus exclusively on the extracranial carotids as a cause of stroke or TIA.
5. In advising patients, recognize that the risk of stroke or death resulting from carotid endarterectomy is highly dependent on the precise clinical indication and the available interventions.
6. Remember that vascular disease is a systemic disease that requires attention to medical risk factors. The systemic disease may be atherosclerosis, but it could also be temporal arteritis or another form of vasculitis.

Special Maneuvers

Carotid Artery Compression in Vascular Headache

Carotid artery pressure may be used as an aid in the diagnosis of migraine and migrainoid headaches (referred to collectively as "vascular headaches"). If the patient is seen early in the attack while the cephalalgia still has its characteristic pulsatile quality, the patient is asked to rate his pain on a scale of 0 to 10. Damping of the pulse wave contour by ipsilateral carotid compression will, early in attacks of vascular headache, be accompanied by a diminution in the pain score. After the compression is released, the pain score tends to return toward the original higher score within just a few beats. This pain relief must be shown not to be replicated with placebo neck stimulation (i.e., rubbing the mastoid process, pinching the skin over the carotid artery without compressing it, etc.). Furthermore, the test is useless once the headache has passed through the pulsatile pain phase and is in the steady pain phase.

This is one of the four criteria associated with vascular headache. To diagnose a vascular headache, any three need to be present in the patient. The others are (a) unilateral pain, (b) throbbing onset, and (c) relief by ergot alkaloids.

Carotid Sinus Reflex

Historic Background

The carotid sinus reflex *qua* reflex was elucidated by Hering, who is probably best remembered for the Hering–Breuer[4] reflex.

A Method (after Lown and Levine, 1961)

1. Tilt the (recumbent) patient's head backward and to the side so that either one of the carotid sinuses can be readily palpated. The sinus is usually situated just below the angle of the jaw at the level of the uppermost portion of the thyroid cartilage (Fig. 18-2).
2. Massage the carotid sinus with pressure directed medially and posteriorly, compressing the artery and the sinus against the vertebral spine.
3. Apply vigorous massage for not more than 5 seconds at a time. The procedure may be repeated after several seconds' rest.
4. Never massage both carotid bodies at the same time.

If this technique is carefully followed, adverse consequences are extremely uncommon. These primarily result from interference with cerebral blood flow. Accordingly, the maneuver should be avoided in patients with historic or physical evidence of cerebrovascular disease (e.g., a carotid bruit) and in patients over the age of 75. Patients with coronary insufficiency may develop

FIGURE 18-2 The carotid sinus. (Adam, by Michelangelo. Detail from the Temptation and Expulsion, Sistine Chapel.)

[4] Breuer is also remembered as the partner of Sigmund Freud in the early studies of the technique that led to psychoanalysis.

asystole (Lown and Levine, 1961). In a study of 1,000 patients 50 years or older who had a history of syncope or unexplained falls, diagnostic carotid sinus massage provoked transient neurologic symptoms in 1% and persistent neurologic complications in 0.1% (Richardson et al., 2000).

A safer way of slowing the heart rate without medication in older patients, in whom there is some risk of dislodging a carotid plaque, is to use the oculocardiac reflex (see Chapter 26) (L. Huntoon, *personal communication*, 2004).

Customary Response

The carotid sinus baroreceptors send the afferent impulses to the cardiac and the vasomotor centers in the medulla via cranial nerve IX. The efferent arc involves stimulation of parasympathetic (vagal) activity, which immediately slows conduction in the SA and AV nodes, causing a chronotropic and bradydromic[5] effect on the heart. After several seconds, there is also an independent inhibitory effect on the sympathetics, causing a drop in blood pressure through vasodilatation. The carotid sinus reflex results in a variable effect on respiratory rate (Lown and Levine, 1961).

It is well recognized that most subjects with cardiovascular disease have a brisk carotid sinus reflex but many normal subjects do not. Some type of cardiac response is elicited in 82% of persons over the age of 40 but in only 18% of those under 40, possibly because of the coexistence of cardiovascular disease in the older group.

Slowing of the sinus rhythm is seen in only 5% of normal subjects. A fall in the systolic blood pressure occurs in 60% of subjects. Again, the figure is higher for older subjects and for those who have cardiovascular disease. Less hypotension is evoked in healthy soldiers.

Some Differential Diagnoses of Arrhythmias Made with the Carotid Sinus Pressure

1. *Regular bradycardia*. A sinus bradycardia gradually slows further during carotid sinus massage. As with many second-degree heart blocks, in paroxysmal atrial tachycardia with a 3:1 AV block, an effective carotid sinus reflex can cause an irregular or jerky slowing of the heartbeat with an irregular or jerky reacceleration when the pressure is removed.

   Paradoxical acceleration of the ventricular rate during carotid sinus stimulation is a specific clue to a 2:1 block. The vagally induced slowing of atrial impulses permits the previously blocked alternate impulse (which had reached the AV node when it was refractory to conduction) to now pass through. Thus, conduction is now 1:1 and the ventricular rate is faster (Fig. 18-3).

   (Complete heart block is not affected by carotid sinus pressure but can be identified by observing the variability in the first heart sound [S1] [see Chapter 17].)
2. *Regular rhythm, with the rate between 70 and 100*. Such a rhythm is naturally assumed to result from a normal sinus mechanism. However, if carotid sinus pressure produces an abrupt slowing or halving of the rate, with a jerky return after the pressure is released, it should suggest to you that the mechanism is not sinus but rather atrial flutter or paroxysmal atrial tachycardia with block.

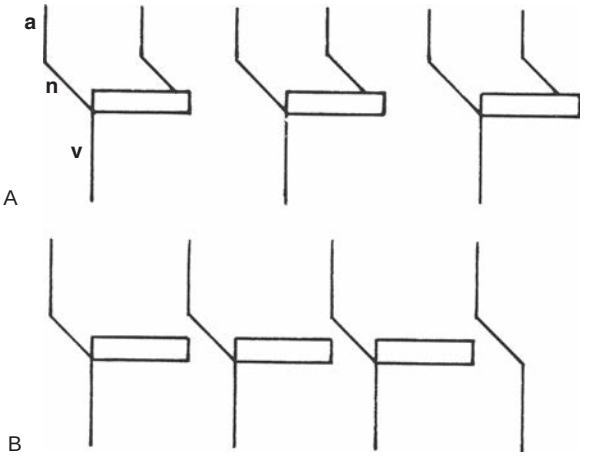

Figure 18-3 **A:** Ladder diagram of a 2:1 AV block. The vertical dashes in the row labeled *a* symbolize atrial depolarizations. The vertical dashes in the row labeled *v* symbolize ventricular depolarizations. The diagonals in the row labeled *n* represent nodal transmission. The rectangles indicate the refractory period in the nodal tissue, their breadth being proportional to duration. Note that alternate atrial impulses reach the node during the refractory period and thus are not transmitted to the ventricle. Because there are twice as many atrial impulses as ventricular ones, the block is called 2:1. **B:** The effect of carotid sinus pressure. The atrial rate is slowed, but the ventricular rate is paradoxically increased because the atrial impulses arrive after the refractory period (itself unchanged) has passed. Whenever carotid sinus pressure causes an increase in ventricular rate, consider that that may be the mechanism.

3. *Rapid regular rhythm*. When the heart rate is regular and rapid (between 120 and 300 beats per minute), carotid sinus stimulation is useful even if you cannot study the patient with an electrocardiogram (ECG).
   a. If the carotid sinus stimulation abruptly stops the tachycardia, but the rhythm remains slow (<100 beats per minute) and regular after the release of pressure, one was probably dealing with paroxysmal atrial tachycardia.
   b. If carotid stimulation temporarily slows the ventricular rate, you can be sure that the arrhythmia is not ventricular tachycardia.
   c. If the slowing of the rate with carotid sinus pressure is smooth and gradual with a similar smooth and gradual return to the original rate after release, it must be sinus tachycardia. This smooth deceleration and reacceleration has been likened to a train slowing down (without stopping) at a station to pick up a mailbag and then speeding up to its original rate.
   d. If recovery from the temporary slowing is jerky, you must again think of atrial flutter or paroxysmal atrial tachycardia with block.
4. *Rapid, irregular rhythm*. If the original rate is rapid and irregular but the slowed heart rate is regular, atrial fibrillation has been excluded. However, if the heart slows while maintaining an irregular rhythm but exercise accelerates and regularizes it, the differential diagnosis includes atrial flutter, premature beats, or paroxysmal atrial tachycardia with block (Lown and Levine, 1961).
5. *Digitalis intoxication*. Because digitalization may sensitize the carotid sinus reflex, carotid sinus stimulation can be used as a nonpharmacologic test for the presence of digitalis intoxication even before the characteristic arrhythmias occur spontaneously. If such stimulation produces advanced degrees of heart block,

[5] Bradydromic is derived from the Greek *brady* (slow) and *drome* (run); it refers to the slowing of atrioventricular (AV) conduction.

ectopic beats with fixed coupling, or the emergence of rapid and regular ventricular response in a patient with atrial fibrillation (representing conversion to a nodal ventricular rhythm while the atria continue to fibrillate), digitalis intoxication is highly likely, especially if carotid sinus stimulation did not previously cause these events in a particular patient.

6. *For the very advanced student 2:1 AV block and 2:1 sinus exit block*. There is no electrocardiographic way to distinguish a 2:1 AV block from a 2:1 sinus exit block, a distinction that can be significant both in terms of underlying diagnosis and, in the case of the former, in the use of drugs that could further slow AV conduction. Should carotid sinus pressure increase the block (slow the pulse), the diagnosis of AV block would seem secure. Conversely, if there were no effect, the test would be suggestive of sinus exit block, although it would not be definitive.

It was formerly taught that the right carotid artery should be massaged to affect the sinus node and that the left carotid should be massaged to affect the AV node. I know of no data to support this. Can you think of a good senior medical student project based upon the testing of such a hypothesis?

The Levine Test

Carotid sinus massage sufficient to produce bradycardia may relieve chest pain due to angina pectoris. Although the Levine test was first described by Wassermann, his eponym was already associated with a serologic test (for syphilis). The test is known today as the Levine test for the man who popularized it.

A Method:

1. Have an attendant (or the patient if no one else is available) hold the stethoscope over the precordium so that you can listen for the bradycardia. Both your hands are now free so that one can be used to brace the patient's head and one can be used to massage the carotid sinus by the method described earlier in this chapter.
2. Establish that the pain is still present.
3. Massage the right carotid first. If this does not produce appreciable cardiac slowing, massage the left.
4. Once slowing has occurred, ask the patient whether the pain has become *worse*.

If the heart rate has been slowed, the patient with angina pectoris behaves in a characteristic fashion: There is a pause before the answer is given, frequently with a look of uncertainty and puzzlement, "No doctor, the pain is all gone" or "It is letting up." Disappearance or lessening of the pain occurs within several seconds of the onset of slowing of the heart though the heart may promptly reaccelerate. Generally, the pain does not recur. Of importance in the proper performance of the test is the exact wording of the question. The objective is to mislead the patient by suggesting that this maneuver has aggravated the chest discomfort. If, despite this misdirection, the patient says the pain has lessened or disappeared, one can be certain that the subjective change is real and has not been suggested by the examiner (Lown and Levine, 1961).

I prefer not to lead witnesses, especially overly cooperative ones, in any direction. Therefore, I have modified the test as follows: I ask for a baseline measurement of pain on a 0 to 10 scale. Then, I ask what number the pain is during the pressure. Unless the pain has gone, I repeat the baseline and experimental measurements while performing placebo maneuvers: rubbing the mastoid, pinching the skin over the carotid sinus, and so forth. (Note that in a *scientific* study, the placebo should be used first half of the time and second half of the time.)

This test is diagnostic of angina pectoris when positive, provided that the same pain relief scores were not obtained with the placebo maneuvers. (However, if negative, it does not rule out angina pectoris as the cause of the chest pain.)

Carotid Sinus Reflex in Left Bundle Branch Block

Slowing the ventricular rate with carotid sinus massage may sometimes eliminate left bundle branch block temporarily, permitting you to inspect the ECG for the signs of anterior myocardial infarction, which can be impossible to detect in the presence of left bundle branch block.

Therapeutic Use of the Carotid Sinus Reflex in Pulmonary Edema

Carotid sinus stimulation has been found effective in alleviating pulmonary edema in 80% of hypertensive or ischemic cases. Relief is immediate and coincides with the onset of bradycardia. The episode may be completely reversed. Carotid sinus stimulation has been carried out intermittently (i.e., for no more than 5 minutes at a time) for as long as 30 minutes. If the reflex becomes extinguished on one side, a good response may be elicited by stimulating the other side. This technique has not been effective in the presence of atrial fibrillation or aortic valve disease (Lown and Levine, 1961).

Carotid Sinus Syncope

When I was a medical student, I was told the following story:

Clinician Soma Weiss was once presented the case of a Boston streetcar conductor who experienced syncope every morning at a certain street corner but at no other time. Apparently, at this particular corner, the conductor had to turn the car and his head to the right. In those days, streetcar conductors wore wing collars (Fig. 18-4). Weiss hypothesized that the stiff starched collar was pressing into the patient's carotid sinus causing a reflex bradycardia or asystole. He tested the hypothesis by pressing with his fingers on the supine patient's carotid sinus, reproducing the symptoms.

After hearing this story, I faithfully inquired about the tightness of the collar in all my patients admitted with syncope. However, by this time, the wing collar had given way to the modern low cut collar of soft cloth, so my inquiries were diagnostically fruitless, as I would have known had I read the original paper (Weiss and Baker, 1933) instead of listening to stories:

> This 65-year-old white streetcar motorman entered the hospital complaining of dizziness and fainting attacks. His symptoms began about 18 months previously when, one day while running his car, he suddenly felt very dizzy and lost consciousness. He started to fall, but was caught by a man standing behind him and regained consciousness immediately. He had another similar attack some months later while running the streetcar. Quite frequently, while working, he noticed dizziness and diplopia. These were always brought on by turning his head from side to side watching traffic. Moreover, he had eight or ten fainting attacks while at home reading. It was always his custom to wear a celluloid collar which was quite loose. When he sat reading, his neck slipped down into the

A B

FIGURE 18-4 **A:** A wing collar with tie removed to show how the stiff, starched, angled point of the wing collar might press the carotid sinus. **B:** Celluloid collars. This must be the type of collar that Armand's wife stuck her finger under (see text).

collar in such a fashion as to press against the right carotid sinus. This fact was not brought to light until we started our investigation. During the 18 months preceding that, he consulted several physicians, who were unable to find any cause for his fainting. Finally, he was examined by Dr Walter Burrage at the Massachusetts General Hospital, who pressed on the right carotid sinus and immediately precipitated a fainting attack. The patient stated that this was entirely similar to his spontaneous attacks. He was referred to us for study.

Routine physical examination was negative except for slight enlargement of the heart and generalized arteriosclerosis. Blood counts and urine were normal. Blood pressure was 136/72. Kahn [serologic test for syphilis] was negative. Electrocardiogram was normal. Both carotid arteries were readily palpable. Pressure on either carotid sinus caused slowing of the pulse, fall in blood pressure, dizziness, fainting and convulsions. Pulse and blood pressure measurements were made with the patient turning his head from side to side while wearing one of his celluloid collars. These movements caused pressure on the carotid sinuses and resulted in slight slowing of the heart rate, fall in blood pressure as much as 40 mm Hg systolic, sometimes dizziness, but not fainting. The patient was advised to wear a soft collar which he has done for the past month. In that time he has had no more attacks of dizziness or fainting.

As a Gallic footnote in the interest of truth, consider the following case report (Roskam, 1930):

> Last November 3, there presented in my consultation room a chief quarryman named Armand C. who was 53 years old and gave a history that before May of 1929 nothing particular had happened....
>
> In May of 1929 the wife of our patient while helping him to put on a very tight collar slipped a finger between the rigid collar and his neck: Immediately her husband collapsed in a faint....
>
> On the 3rd of November while in Liege on business he went to a barber. Here, when the razor went over his neck it provoked a sudden and prolonged syncope....
>
> [This has been understood in English to mean a carotid sinus so sensitive that syncope occurred when the skin over the sinus was barely touched by a razor. It would not be possible to stimulate the carotid sinus in that way. No doubt what Armand remembered was the razor going over his neck. But when a barber shaves a customer's neck, the thumb that is not holding the razor is used to straighten the customer's skin, and this is done by pressing up the neck toward the angle of the jaw (i.e., over the carotid sinus), as the reader may observe by visiting a barber shop. Thus, I think the razor has been unjustly accused all these years, when the real culprit must have been the barber's thumb pressing on the carotid sinus.]
>
> I systematically searched by strong compression in many places of the carotid and paracarotid regions of my patient carefully going over the left carotid and above the region of the left carotid sinus but not getting any noticeable reaction. I then approached the carotid sinus itself going at the level of the thyroid cartilage to the inferior angle of the jaw. Hardly had I begun to compress—I hesitate to say I even touched it—when Armand C. cried in a voice strangled with anguish, "I'm going." Immediately I ceased the compression which had been only an instant. Armand C. was pale as death, his lips without any color, his eyes dim, lying totally inert without consciousness, without movement, without pulse, without respiration. When the syncope went on more than 15 seconds after I had stopped pressing on him, I ausculted the precordial region with great attention: There was absolute silence. Finally, there supervened a grand mal seizure....[The patient survived the episode and went back into normal sinus rhythm.]

Notice that this report predates that of Soma Weiss.

We previously noted that the carotid sinus reflex could be useful as a diagnostic tool or even a therapeutic one, although it was missing in many normal persons. Now, we have described a disease caused by a hyperactive carotid sinus reflex. The question is: At what point does a carotid sinus reflex merit the adjective "hyperactive"?

For screening purposes, a carotid sinus reflex is arbitrarily called *hyperactive* (Lown and Levine, 1961) if there is a greater than 50% slowing of the heart rate or a greater than 40 mm Hg drop in the systolic blood pressure (during carotid sinus massage). Of all the persons who meet these criteria, only one third will have symptomatic carotid sinus syncope. Thus, if the patient does not meet these criteria, a hyperactive carotid sinus reflex is ruled out. However, if a patient with syncope does meet the criteria for hyperactive carotid sinus reflex but the symptoms are not reproduced by carotid sinus massage, one still has not diagnosed carotid sinus syncope.

Carotid sinus syncope may be the mechanism for tussive (cough) syncope (Wenger et al., 1980), which is most likely to

occur in patients with chronic obstructive pulmonary disease and well-developed thoracic musculature. Among the many other suggested mechanisms for tussive syncope are AV dissociation (Saito et al., 1982), reflex vasodilation (Chadda et al., 1986), or possibly decreased cerebral blood flow caused by increased venous pressure.

The prevalence of carotid sinus hypersensitivity has been found to be as high as 4% in asymptomatic adults and may be a contributory cause in 25% to 45% of older patients with unexplained syncope. Carotid sinus hypersensitivity was found in 35% of patients admitted with a fractured neck of the femur and in none of an age-matched control group admitted for elective hip surgery (Richardson et al., 2000).

Subclavian Steal Syndrome

In patients complaining of neurologic or left–upper-extremity symptoms, especially if brought on by exercise, you should always compare the blood pressure and pulses of the left arm with those in the right in order to identify patients with the surgically reversible subclavian steal syndrome. The word "steal" refers to the exercise-induced theft of blood from the vertebral artery caused by occlusion of the subclavian artery proximal to the origin of the vertebral artery. Although at first it seems startling to consider, such occlusions actually lead to a reversal of flow (arteriographically demonstrated) in the ipsilateral, usually left, vertebral artery. In other words, the blood goes first to the brain, and then to the arm, bypassing the traffic jam in the subclavian. In the old days, we made the diagnosis by history. Typically, a man (60% of cases occur in men) in his fifties (±10 years) complained of sudden vertigo, ataxia, lightheadedness, confusion, headache, and/or visual disturbances while brushing his crew cut with his left hand. In one third of the cases, there are hemispheric rather than vertebrobasilar symptoms and these might include transient (or even completed) monoplegia or hemiplegia or, rarely, transient blindness. About 12% of patients have no neurologic symptoms but rather exhibit upper-extremity claudication,[6] easy fatiguability, and weakness of an intermittent and transient (i.e., not strokelike) nature. Such symptoms can also accompany the neurologic symptoms in about 50% of the patients experiencing the latter.

In more than 85% of the patients, the syndrome is acquired (i.e., atherosclerotic) and left sided. On physical examination, such patients have absence or diminution of the left radial pulse (compared with the right) and/or a left brachial systolic blood pressure that is 20 mm Hg less than that on the right. The remainder either have a congenital or traumatic cause, right subclavian steal syndrome or bilateral disease, confounding the comparative study of the upper-extremity arterial circulation (Larrieu et al., 1979; Lawson et al., 1979).

Cases of a coronary subclavian steal, and of a concomitant cerebral and coronary subclavian steal, have been reported (Takach et al., 1997).

[6] The word "claudication," meaning "limping," derives from Claudius, the limping Emperor of Rome. From a strict semantic viewpoint, one should not speak of claudication of the upper extremities, but the other manifestations of exercise-induced ischemia are analogous in the upper and lower limbs.

Internal Carotid Artery

Direct Palpation

The internal carotid cannot be palpated in the neck. A method for palpation in the posterior wall of the pharynx, under the pharyngopalatine muscle, has been described (Dunning, 1953). This is most commonly carried out by vascular surgeons intraoperatively.

Ocular Pressures

The determination of ocular pressures by ophthalmodynamometry or ocular plethysmography is primarily of historic interest (see discussion in Sapira [1990]). These are seldom used, having been replaced by the carotid duplex study, which is much more sensitive and probably about the same cost as the ophthalmologic consultation required to obtain the pressures.

Some have used ophthalmodynamometry in the diagnosis of intracerebral postural hypotension (Hollenhorst and Kublin, 1963). Apparently, some individuals can have postural hypotension of the retinal arteries (and presumably of the cerebral circulation) with no significant detectable change in the brachial artery blood pressures upon assuming the erect posture.

Auscultation: Fisher's Contralateral Systolic Bruit

A sign of contralateral internal carotid artery occlusion, Fisher's contralateral systolic bruit is heard at the carotid bifurcation, the eyeball, and over the skull (not necessarily in all three places in a given patient). Semeiophysiology is total occlusion on the silent side and collateral increased flow producing the murmur on the normal side. The sensitivity was initially reported to be 100% although there was mention of a patient with the bruit only at the carotid bifurcation and not at the eyeball. Other patients had the murmur missing over the skull (Fisher, 1957). However, a later study found the sensitivity of the contralateral carotid murmur to be only 10% (Silverstein et al., 1960b) and the sensitivity of the contralateral murmur specifically over the eyeball to be only 5% (Edwards et al., 1960).

False positives were not initially quantitated; Fisher described them as "a rarity." Later, no false positives were found for the eye or the skull murmur (Welch and Crowley, 1970), although there was a 3% false-positive rate for the carotid murmur indicating the wrong side (Silverstein et al., 1960b) (i.e., being ipsilateral rather than contralateral to the lesion).

Other causes of bruits over the skull and eyeballs are discussed in Chapter 9.

Dynamic Auscultation: Distinguishing Internal and External Carotid Bruits

About 10% of carotid bruits actually originate in the external carotid arteries (Allen and Mustian, 1962; Kurtz, 1984; Peart and Rob, 1960). The effect of various maneuvers on bruits originating from the internal versus the external carotid is given in Table 18.3.

Vascular Tinnitus

Some patients who have tinnitus (especially when unaccompanied by other evidence of ear pathology) may have vascular tinnitus (also see Chapters 9 and 11). This is especially likely when

TABLE **18.3** *Distinguishing internal from external carotid murmurs by dynamic auscultation*

Artery	Hyperventilation	Breath holding	Compression of ipsilateral superficial temporal and facial arteries[a]
Internal carotid	Decrease	Increase	Increase
External carotid	Increase	Decrease	Decrease

[a]The facial artery passes beneath the mandible near the angle of the jaw; it is often not palpable in normal persons.
From Kurtz KJ. Dynamic vascular auscultation. *Am J Med.* 1984;76:1066–1074, with permission.

the symptom is unilateral and episodic. If you can examine such patients during an attack, they can often detect a phasic component to the tinnitus. Ask them to time it with hand movements and take the pulse in the other wrist. Simultaneity of the pulse and the variation in the tinnitus support a vascular etiology. If compression of the ipsilateral carotid artery abolishes the tinnitus, the diagnosis is clinched.

Temporal Arteries

The temporal arteries are first felt just anterior to the tragus. It is most important to palpate them in patients in whom temporal arteritis, giant cell aortitis, Takayasu arteritis, or polymyalgia rheumatica is suspected, including patients with headache or unilateral visual problems. In temporal arteritis, the temporal arteries may be nodular, inflamed, or tender—or, in about half the cases, normal. Rarely, the temporal artery pulsation can be felt only on one side, a finding that is almost pathognomonic of temporal arteritis (on the side where the pulsation is absent). Ideally, these arteries should be palpated in all patients as a guide to the general state of arterial sclerosis throughout the body. Furthermore, one must learn what they feel like in normal persons so as not to equate the arterial sclerosis of aging with the findings of an inflamed artery.

Because early diagnosis is so important, as to prevent blindness, temporal arteritis should be considered in any patient over the age of 50 complaining of persistent unexplained pain above the neck. The only distinguishing feature of headache from this cause may be its newness. Classic symptoms, which occur in about 60% of patients, include headache (77%), jaw claudication (pain with protracted chewing) (55%), constitutional symptoms (48%), polymyalgia rheumatica (34%), visual symptoms (29%), fever (26%), an abnormal temporal artery (53%), and an erythrocyte sedimentation rate (Westergren) greater than 40 mm per hour (94%). About 40% present with atypical symptoms, which may include respiratory complaints (present in 10%), tongue pain, or large artery involvement (*vide infra*) (Hellmann, 2002).

A review of 41 studies that met inclusion criteria found that of historic findings, jaw claudication had the highest positive LR (4.2) for temporal arteritis but was present in only 34% of cases. Diplopia was the next most predictive historic feature (positive LR 3.4) but had only a 9% sensitivity (Smetana and Shmerling, 2002).

Additional physical findings to check for include ischemic or necrotic changes on the scalp or tongue and pallor or swelling of the optic disc. The only physical finding that, when absent, substantially decreases the probability of temporal arteritis is any abnormality of the temporal artery (Smetana and Shmerling, 2002).

It is not surprising that orbital bruits owing to retinal ischemia are often heard in patients with temporal arteritis (Gilbert, 2002).

Subclavian Artery

The subclavian artery is located in the anterior medial corner of the supraclavicular fossa in the angle of the posterior aspect of the clavicular insertion of the sternocleidomastoid. Normally, the pulsations are equal and there usually are no bruits.

Patients undergoing hemodialysis typically have supraclavicular bruits on the same side as the dialysis access (Wheeler, 1982). These can be heard between dialyses in 72% to 93% and during dialysis in 38%. Transient (<5 seconds) brachial artery occlusion (by manually squeezing it) causes the murmur to disappear.

Thoracic Outlet Syndromes

A variety of symptoms in the upper extremities, primarily pain in the neck, shoulder, and arm (82%) and numbness or tingling (82%), have been attributed to compression of the neural and vascular structures as they exit from the thorax. Less common are swelling (24%) and cyanosis (12%) (Heughan, 1984). Many other names have been given to the syndrome, and most of the symptoms are caused by nerve trunk compression (see Chapter 25).

A large number of maneuvers have been recommended to make this diagnosis. In each of these, one palpates the ipsilateral radial artery while listening for a bruit over the subclavian artery. Disappearance or diminution of the radial pulse, and/or the appearance of a bruit over the subclavian artery, constitutes a positive test. It has been found, however, that the same pulse changes can be elicited in 30% to 50% of the normal population. In fact, the radial pulse could be obliterated by hyperabducting the shoulder in 82% of asymptomatic army recruits (Wright, 1945).

Vascular Anomalies

An aberrant origin of the right subclavian artery occurs in about 1% of the population and is the most common congenital abnormality of the aortic arch. Most commonly, the aberrant artery arises distal to the left subclavian artery and passes behind the esophagus to the right arm. Sometimes it passes between the trachea and esophagus. This may produce unexplained stridor or dysphagia (see Chapter 14) known as *dysphagia lusoria* ("dysphagia of a joke," the joke being one that nature performed upon the patient). Vascular ring anomalies may have the same effect. Other symptoms include chest pain, coughing, and right arm discomfort. Although most often an asymptomatic finding discovered incidentally at surgery or on a chest radiograph, the aberrancy can cause life-threatening symptoms that can be confused with pericarditis or aortic dissection (Bisognano et al., 1997).

Axillary and Brachial Arteries

The importance of checking the blood pressure in all four extremities has been discussed in Chapter 6; review this material now.

The axillary artery may be involved in temporal arteritis. This may be detected by listening for a bruit on the flexor surface of the upper arm. If concerned about this possibility, you will also have listened above and below the clavicle for bruits over the subclavian artery (Hellmann, 2002).

Wrist Arteries

Palpation of Radial Artery

Both radial and ulnar arteries should be palpated routinely. I can still see and hear Dr Jack Myers exclaiming, "Everyone takes the pulse but no one bothers to feel the vessel," as he proceeded by radial artery palpation to diagnose yet another case of Monckeberg sclerosis or perhaps simply arteriosclerosis as the cause of what is now called "pseudohypertension" (see Chapter 6).

Perloff recommends using the thumb for radial arterial palpation because the artery will never roll. This is exactly why I always palpate with my fingers. If there is a sclerosed artery (sclerosed, not stenosed) that rolls from my fingers, I have found an abnormality and informed myself of a potential difficulty in performing an arterial puncture. Also, using several fingers will help in determining how deformable the artery is and will also help in perceiving the pulse wave contour.

Although anacrotic notches, dicrotic notches, and bisferiens pulse can be detected at the radial artery, it makes more sense to feel for pulse contour at the carotid artery. However, the ability to detect and time the peak of the radial systolic pulsation enables one to compare it with that of the femoral artery pulse, simultaneously palpated with the other hand.

Normally, the peak of the arterial pulse waves occurs in the femoral artery before it occurs in the radial because the radial artery is actually farther from the heart. This sequence is reversed when there is an obstruction in the aorta above the femoral artery. Most commonly, such an obstruction is caused by coarctation of the aorta in a young person and by severe aortic atherosclerosis in an older person. (Such severe obstruction is actually a rare event in atherosclerosis; however, patients with undiagnosed and untreated coarctation of the aorta do not usually live into the age groups that develop severe atherosclerosis.)

Palpation of Ulnar Artery

Many people have difficulty finding the ulnar pulsations, which are absent in only 3% of the population (Spittell, 1983). Be sure that you are far enough toward the ulnar side. Passively extend the wrist to move the artery closer to the surface. Use three fingers so that you are more likely to encounter the pulsation despite the vagaries of its location.

The Allen Test

My modification of the Allen test for patency of the deep palmar arch is performed as follows:

1. Compress the patient's right radial artery using at least three of your fingers or your thumb to obtain a secure purchase.
2. Have the patient vigorously clench and unclench his right hand three times to make it blanch. Observe the filling from the ulnar artery. Release the radial artery pressure.
3. Repeat on the left. Did both palms show the same pink area? Did refilling occur over both palms with equal speed?
4. Repeat the above sequence, compressing the ulnar arteries.

Several students have shown me a modification of the Allen test, which they use to predict ulnar artery patency in patients who are about to have a radial artery puncture for an arterial blood gas determination. This modification seems superior to my generation's technique of simply palpating the ulnar artery pulsation.

1. Compress both the radial and the ulnar arteries as the patient clenches his fist until it blanches.
2. Release only the ulnar artery to see if the hand will pink up. (If it does not, you might want to do a brachial artery stick.)

Other Tests for Digital Arteries

For the Very Advanced Student. In the original paper, there are other tests described for the digital arteries (Allen, 1929):

1. Look for excessive pallor in some but not all digits after 2 minutes of elevation.
2. Look for abnormal rubor in one or more but not all digits after 2 minutes of dependency.
3. Squeeze the blood out of a digit for 5 seconds with the patient's hand elevated. Normally, there should be a return to the normal red color as soon as the pressure is released.
4. Sometimes you can palpate the individual digital arteries at the base of the fingers by laterally grasping the volar digital tissue between your forefinger and thumb. (Another version is to grasp all the patient's fingers at the bases between the bases of your own fingers in the manner of the first grasp of professional wrestlers.)

The Raynaud Phenomenon

Historic Perspective

Medical student Maurice Raynaud's thesis for the doctorate of medicine, entitled "On the local asphyxia and symmetrical gangrene of the extremities," was published in 1862. In it, he described an initial "pallor" that was replaced in more severe cases by a cyanotic color and then a vermillion that finally gave way to the normal pink (Raynaud, 1862). The next year, he described the stage of pallor as being a "gray green pallor" and described the cyanotic stage as being "black" (Raynaud, 1865) in a paper that was brought to my attention by Dr Gerry Rodnan of the University of Pittsburgh. Most authorities (such as the texts of Snapper and Bailey; see Chapter 29) describe the sequence as white followed by blue followed by red. However, blue followed by white followed by red has been seen (Delp and Manning, 1975), as well as only blue or only white (Sutton and Sutton, 1937). I believe that all these may occur, the actual shades being not so important if we keep the semeiophysiology in mind.

Semeiophysiology

The white (pallor) obviously represents blanching and ischemia, the vasospasm having squeezed all the blood out of the fingers, as it were. The final stage of red or vermillion is obviously the reactive hyperemia seen when the zenith of the attack is past and the (compensatory) increased blood flow to the hands is repairing the ravages of the prior oxygen famine. And the blue, whenever it appears, is obviously cyanotic blood of the type of acrocyanosis you can imitate in yourself by placing a rubber band about your finger. Here, the blood is held in prolonged contact with the tissues, and it becomes blue as its oxygen is removed. This could occur early or late, through two different mechanisms. First, the venous capillaries could be in spasm at a time when there is still some arterial flow. In that case, the blood would pour into the fingers and become trapped, just as with the rubber band. Or, the venous capillaries could be completely normal but the arterial side could let in a small amount of blood, still sufficient to color the fingers but with such a slow transit that the tissues could remove enough oxygen to turn the fingers blue.

Criterion for Diagnosis

The diagnosis is made by inducing some form of the phenomenon in one hand by the immersion of the other hand in a bucket of ice water. Where the proclivity for the response has passed and it is not possible to induce it, one is totally dependent upon the history of some triphasic color response, including a white phase (G. Rodnan, *personal communication*, 1977).

Significance

Please note that I have been referring to the Raynaud phenomenon, not Raynaud disease. When the sign first appears, one does not know what condition it heralds (Table 18.4). I take the position that there is no such thing as Raynaud disease, the phenomenon always being a sign of some underlying condition. Even if you were to follow a patient with only the Raynaud phenomenon for 30 years, I could still claim that such a patient would eventually develop other manifestations. (This is not a very sound position scientifically, is it?

TABLE **18.4** *Disorders associated with the Raynaud phenomenon*

- Connective tissue diseases
  - Progressive systemic sclerosis (17%–28%) (++++)
  - Systemic lupus erythematosus (5%–16%) (+++)
  - Mixed connective tissue disease (3%–13%) (++++)
  - Dermatomyositis/polymyositis (1%) (++)
  - Rheumatoid arthritis (1%)
- Blood abnormalities
  - Cryoglobulinemia (and overlap with arteritis cases) (2%–24%)
  - Cryofibrinogenemia
  - Cold hemagglutinins
  - Monoclonal gammopathy
  - Polycythemia
- Occupational
  - Percussion and vibratory tools workers (e.g., chainsaw) (1%–2%)
  - Traumatic occlusive arterial disease
  - Vinyl chloride workers
- Arterial diseases (for vasculitis, see cryoglobulinemia)
  - Thromboangiitis obliterans
  - Thromboembolism
- Arteriosclerosis (1%–13%)
  - Fabry disease
  - Pseudoxanthoma elasticum
  - Polyarteritis nodosa
  - Giant cell arteritis
- Neurovascular compression
  - Thoracic outlet syndromes (see Chapter 25)
  - Crutch pressure
  - Carpal tunnel syndrome
- Drugs and toxins
  - Ergot
  - Methysergide
  - Beta-adrenergic blocking drugs
  - Chemotherapy
  - Vinyl chloride
  - Methamphetamine
- Miscellaneous
  - Reflex sympathetic dystrophy
  - Hypothyroidism
  - Pheochromocytoma
  - Neoplasm
  - Primary pulmonary hypertension
  - Variant angina
  - Addison disease
  - Acromegaly

Note: The percentages are the prevalence of the given disease among all patients with the Raynaud phenomenon; the pluses are a qualitative measure of the sensitivity of the phenomenon for the disease (i.e., a "++++" sensitivity in progressive systemic sclerosis [PSS] means most patients with PSS will have the Raynaud phenomenon, but only 17% to 28% of patients with the Raynaud phenomenon will have PSS).
From Blunt RJ, Porter JM. Raynaud syndrome. *Semin Arthritis Rheum.* 1981;10: 282–308, G. Rodnan (*personal communication*, 1977), and Spencer-Green G. Raynaud's phenomenon. *Bull Rheum Dis.* 1983;33(5):3, with permission.

That is, the hypothesis is not falsifiable [see definition in Chapter 1]). If you wish to say that there is a Raynaud disease, you will initially diagnose it in 20% to 30% of patients with the Raynaud phenomenon (Blunt and Porter, 1981).

Aorta

Aortic Dissection

Sometimes called a *dissecting aneurysm*, or more properly a *dissecting hematoma*, aortic dissection results from an intimal tear. The pulsatile aortic flow creates a false lumen, which propagates. The usual presentation is sudden onset of very severe chest pain, usually described as tearing, with diaphoresis. Symptoms and signs result from compression of adjacent structures and occlusion of the vascular supply.

About 68% of the patients with an aortic dissection are hypertensive (McCloy et al., 1965) despite appearing clammy and restless, as if in shock. A sinus tachycardia is often present. A "double" pulse may result from the sequential filling of the true and false lumen. The extremity blood pressures may be unequal (see Chapter 6). A cold pulseless extremity suggests vascular occlusion at the aortic takeoff. A warm pulseless extremity is a sign that the dissecting hematoma has performed an autosympathectomy (Glenn, 1983). An aortic insufficiency murmur may be heard if a proximal dissection has involved the aortic valve, or murmurs may be heard over major branches such as the carotid or subclavian (Wheat and Palmer, 1971). In the rare instance of dissection with reentry, there may be a bruit over the abdominal aorta (Rivin, 1972).

The Potain sign is described in Chapter 17. Signs of a widened superior mediastinum should also be sought on chest radiograph.

A patient with a spiral dissection of the aorta, who was attended to by this author, had cyanosis of the left side of the abdominal wall, demarcated by an old midline surgical incision, and a pulseless and flaccid right arm and left leg.

Aortic dissection can present with neurologic findings only, and the findings may be transient. Ischemic lumbosacral plexopathy has been thought to be consequent to occlusion of the lumbar segmental arteries, as well as branches of the iliac artery (García-Díaz et al., 1988).

A unilateral femoral pistol-shot sound has been described in a patient with an aortic dissection and no evidence of aortic regurgitation (McGee and Adcox, 1995).

Saccular Aneurysms

The physical findings of a saccular aneurysm of the thoracic aorta might include a diminished blood pressure in the left arm, an aortic insufficiency murmur due to dilatation of the aortic root, an increase in retrosternal manubrial dullness, the Potain sign, and an aortic tracheal tug (see Chapter 14).

Most thoracic aneurysms result from cystic medial necrosis, which is particularly prevalent with Marfan syndrome and Ehlers–Danlos syndrome type IV. Physicians need to have a high index of suspicion for this life-threatening complication in patients with Marfan (see Chapters 5, 10, and 24). Pregnant Marfan patients are at high risk; consider monitoring the diameter of their thoracic aorta ultrasonically.

A surprising number (18%) of patients with temporal arteritis have involvement of the aorta, most commonly a thoracic aortic aneurysm though acute dissection has also been reported (Hellmann, 2002).

A saccular abdominal aortic aneurysm is a pulsatile mass that usually is readily palpable on routine examination of the abdomen. It is important to look for this frequently lethal condition, which was found in 6% of men over the age of 65 in a large screening program in England (Lederle, 1990).

Two Methods

1. An aneurysm must be distinguished from a viscus that is simply transmitting a pulsation. Put your hands on both sides of the pulsation and see whether it moves them apart. A viscus that is simply being knocked about by extrinsic forces does not expand, whereas an abdominal aortic aneurysm does.
2. Because it is fixed proximally and distally, an abdominal aneurysm cannot be moved cephalad or caudad in a longitudinal direction on bimanual palpation but it can be moved laterally (Guarino, 1975).

Aneurysmal Size

By direct measurement (e.g., during an autopsy or ultrasound), a normal adult infrarenal aorta is about 1.8 cm in diameter; most agree that a diameter greater than 3.5 cm is "aneurysmal" (Fortner and Johansen, 1984). But the normal width of the aorta in older patients, as judged by indirect means, is stated to be 4 to 5 cm (Wiener and Nathanson, 1976–1977).

Large aneurysms, and those increasing rapidly in size, are most prone to rupture (Bernstein et al., 1976; Crane, 1955). However, palpation is an unreliable method for judging the size. Once an aneurysm is detected, following the diameter by physical examination may be helpful if a clear increase is noted but failure to discern an increase does not mean an increase has not occurred.

The tension on the aortic wall follows the law of Laplace: tension (T) = intraluminal pressure (P) × aortic radius (r). The risk of rupture thus increases with diameter and systemic hypertension. In an autopsy series of 44 patients with abdominal aortic aneurysms, 82% of aneurysms larger than 7 cm had ruptured fatally, whereas only 4% of those under 6 cm had done so (Crane, 1955). Even aneurysms of 5 cm do rupture, albeit rarely. The average growth rate is 0.4 cm per year (Bernstein et al., 1976).

Diagnosticity of Palpation

Sensitivity

Palpation is 28% to 69% sensitive compared to 56% for conventional radiography (Lederle et al., 1988; Robicsek, 1981). Palpation is 100% sensitive in screening patients with an abdominal girth less than 100 cm but is otherwise inferior to ultrasound and computerized tomographic (CT) scans, which are 100% correct (Lederle et al., 1988; Robicsek, 1981).

False Positives

Because a tortuous aorta may be mistaken for an aneurysm, it is not surprising that the predictive value (PV) of a positive test for a "definite" pulsatile mass or aneurysm has ranged from 100% (Robicsek, 1981) down to 50% (Lederle et al., 1988).

Auscultation

Systolic bruits are heard in 28% of abdominal aneurysms (Estes, 1950). The differential diagnosis of such a bruit is discussed below.

Associated Clinical Findings

About 4% of patients with abdominal aortic aneurysms will also have another aneurysm. But more than 60% of patients with peripheral (e.g., femoral or popliteal) aneurysms also had a concomitant abdominal aortic aneurysm (of which 40% were overlooked on the physical examination) (Dent et al., 1972). (Can you deduce from the Laplace equation why peripheral aneurysms predict aortic aneurysms more than vice versa?) (The answer is in Appendix 18.1.)

Findings with a Ruptured Aneurysm

A leaking abdominal aneurysm causes the diagnostic triad of back, flank, or abdominal pain; a pulsatile abdominal mass; and hypotension. Such patients should be taken to the operating room without delaying for diagnostic studies (Fortner and Johansen, 1984).

Case Report

A 78-year-old white man, who was being treated for diabetes and hypertension, gradually developed fatigue and difficulty walking. Then, he acutely experienced back pain, which moved to his right hip. He did not seek medical help immediately, but rather kept his appointment with his regular "primary care provider" 2 weeks later. Ordinarily, he went to the office by himself. This time, his wife accompanied him, and he used a walker. The nurse mentioned that his blood pressure was low, 90/60. He said, "That's better than high." The nurse replied, "Not necessarily." The doctor glanced briefly at the blood sugar measurements that the patient took at home, gave him a "pain shot" for his hip, and instructed him to let the doctor know if he was not better in 2 weeks. A week later, the patient went to the bathroom at 4:30 a.m. and was unable to get off the toilet. He began to complain of stomach pain. Emergency responders took him to the hospital, where he was promptly taken to the operating room.

What operation was done? Should the diagnosis have been made in the "primary care" office? Answers in Appendix 18.2.

Traumatic Aneurysms: A Historic Interlude

The term "aneurysm" derives from the Greek word for "a widening." The condition has been recognized since the earliest days of medical history. In the second century AD, the accomplished and daring Greek surgeon Antyllus treated many traumatic aneurysms caused by spear injuries, accurately describing proximal and distal ligation and evacuation of the aneurysm sac. His method was forgotten during the Middle Ages and revived during the Renaissance.

At a time when surgeons could only ligate blood vessels, not reconstruct them, collateral circulation was crucial for the viability of a limb. John Hunter, the first surgeon to recognize this, proposed to ligate the artery at a distance distal to the aneurysm. His famous operation for popliteal aneurysm in 1785 was a monumental step forward in vascular surgery.

The characteristic bruit in arteriovenous aneurysm was described by William Hunter in 1761. Nikolai Ivanovich Pirogov (1810–1881), Professor of Surgery at the Medico-Surgical Academy in St Petersburg, advised auscultation of blood vessels to detect an aneurysm in the early stages. He also advised applying the stethoscope to an apparently solid tumor to avoid failure to recognize an aneurysm. His advice was transmitted to his student Nikolai S. Korotkov (also spelled Korotkoff).

Before Korotkov, European physicians were content to measure the systolic blood pressure by palpation. For this purpose, they did not need and did not use a binaural stethoscope. Korotkov developed the auscultatory method, which permitted more accurate determination of the diastolic pressure, in a search for signs of whether a limb afflicted with a posttraumatic arteriovenous fistula would remain viable after surgery. His main concern was choosing "the correct plan of operative treatment" in order to preserve the limb (Konstantinov et al., 1998).

Internists who call their surgical colleagues "Neanderthal proceduralists" should be humbled by the story of Korotkov. This young military surgeon deserves credit for the binaural stethoscopes around our necks and our most common procedure, the measurement of the blood pressure.

Risk Factors

A dissecting or ruptured aneurysm can rapidly cause a preventable death if physicians do not think of the diagnosis. Persons with a family history of aneurysms or Marfan syndrome are at higher risk, but absence of a history does not rule out the problem. Pregnant women with a predisposing condition are at especially high risk because their blood volume has increased by 50% (Helliker, 2004). Do not spare the ultrasound machine or CT scanner in a patient with severe acute pain and no clear explanation—unless you are on the way to the operating room (*vide supra*). You will, of course, have checked the pulse and blood pressure in all four extremities.

Chronic Dissections

Chronic dissecting aneurysms have been discovered during a workup for something else, including chronic cough. Presentation may be atypical, as with syncope or limb ischemia. When an end organ is not being perfused, the problem could be anywhere along the supply line. Don't forget about the main highway, the aorta!

Synthesis of Coarctation

The Legrand periscapular pulsation of the collaterals works well for the diagnosis of coarctation in adults. Sir Thomas Lewis's femoral pulse delay is described in the section on the "Radial Artery." Sir George Pickering first noted that the top of the body is warmer than the bottom. This is a reflection of the blood flow to the two areas and may be visually demonstrated without a thermometer by scratching above the umbilicus (which turns red quickly) and below the umbilicus (which will be white). The significance of upper-limb hypertension has already been discussed in Chapter 6. Finally, the Gerbode sign is useful in children (who may have femoral arteries that are difficult to palpate) as well as adults: The prone patient places a hand on the ipsilateral foot (the knee flexed) behind his back. The physician squeezes the two together, squeezing the blood out. When the compression is released, the hand will immediately pink up, but the foot will

not. This test should also work well in other aortic obstructions (Gerbode, 1976).

Leriche Syndrome

Patients with both exercised-induced ischemia and vasculogenic impotence are said to have Leriche syndrome, which results from aorto–iliac disease.

As a rule, patients are young adults (the youngest of ours was 29), mostly men—but Delannoy reports a case in a woman, aged 41. In general, they come to the physician for one or the other of the following symptoms:

> *In the male: inability to keep a stable erection*, the blood flow being insufficient to fill the spongious processes—If the disease is left to itself, sexual impotency will soon be permanent.
>
> *Extreme liability to fatigue of both lower limbs*. It is not the well-known "intermittent claudication," but an extreme weariness, which comes quickly on walking, sometimes even in ordinary standing position.
>
> *Usually a global atrophy of both lower limbs,* which is difficult to appreciate as a normal limb lacks as a term of comparison. One must be on one's guard, not to overlook bilateral atrophy.
>
> *No trophic changes*, either of the skin or of the nails. Toes look normal. It is difficult to believe that the circulation is severely impaired....
>
> *Pallor of the legs and feet*, even when standing. At rest, the limb looks as if a Martin rubber bandage had just been released. When the legs are raised to the vertical, the pallor becomes striking, being like ivory or marble.
>
> *The clinical investigation* reveals, moreover, that no pulse can be found, either in the leg or in the groin. The iliac pulse is not felt. That of the aorta will be perceived very high up, above the umbilicus....One should never diagnose a "neuritis" or a "polyneuritis" of the lower limbs, unless one has carefully examined the femoral pulses and the oscillometric curve (Leriche and Morel, 1948).

Penile Artery

In patients with a history of impotence, the nocturnal tumescence (postage stamp) test (see Chapter 3) may point to vascular insufficiency as a possible etiology.

The Doppler device may be used to measure penile artery pressures. A gradient of 40 mm Hg between the brachial and the penile systolic blood pressures is evidence of vascular occlusive disease (Barry and Hodges, 1978). Others have used the penile–brachial systolic blood pressure ratio, stating that a ratio less than 0.6 is diagnostic of vasculogenic impotence, ratios between 0.6 and 0.75 are compatible with vasculogenic impotence but are not necessarily diagnostic, and a ratio greater than 0.75 is compatible with normal pelvic hemodynamics (Goldstein et al., 1982).

Because measurements under resting conditions may be inadequate, a pelvic steal test (comparable to the DeWeese test, discussed later in this chapter) has been described (Goldstein et al., 1982). After the resting brachial and cavernosal pressures were determined, patients were asked to flex and extend their ankles against a resistance for a maximum of 3 minutes or to the point of claudication or extreme fatigue. A positive pelvic steal test was defined as being any decrease in the penile–brachial systolic blood pressure ratio of 0.15 or more.

Renal Arteries and Other Causes of Abdominal Bruits

Renal artery bruits should be sought in all hypertensive patients.

The kidneys are retroperitoneal, and the renal arteries leave the aorta cephalad to the umbilicus. The areas to auscultate for renal artery bruits are shown in Figs. 18-5 and 18-6.

In addition, listen in the epigastric area and the four quadrants of the abdomen. These areas should also be examined for bowel sounds (see Chapter 20). Just as you listen to one thing at a time while auscultating the heart, listen for one thing at a time in the abdomen. Note the difference in technique: Press lightly for bowel sounds and use moderate pressure to listen for bruits. For reasons discussed in Chapter 20, listen for bowel sounds first before percussing or exerting pressure on the abdomen.

FIGURE 18-5 Anterior abdominal bruits due to renal arterial hypertension may be heard in a band just above the umbilicus. Do not listen anteriorly while the patient is seated like this; have him lie down. (Guiliano de Medici, by Michelangelo.)

Figure 18-6 In listening for posterior renal arterial bruits, start high and work your way down each side, in the region indicated. (Guiliano de Medici, by Michelangelo.)

A Method

When searching for renal artery bruits anteriorly above the umbilicus, press the bell of the stethoscope deep into the abdomen. As the skin of the anterior wall is stretched tightly over the bell, it is converted into a diaphragm, facilitating the recognition of high-pitched murmurs.

A useful trick for preventing pain in the examiner's ear while pressing the stethoscope deeply is to pull out one of the earpieces so as to decompress the system. While still pressing into the abdominal wall, replace the earpiece.

Others recommend using the diaphragm and moderate pressure (Turnbull, 1995).

Diagnosticity of Abdominal Auscultation in Renovascular Hypertension

About 39% to 75% of the patients with renal vascular disease have an abnormally high-pitched anterior systolic bruit radiating laterally toward the flanks (Hocken, 1966; Shapiro et al., 1969). However, normotensive patients can have some sort of anterior abdominal bruit 0% to 16% of the time (Table 18.5). In the essential hypertensive patients, the false-positive rate is 1% to 28%.

A recent review judged three reports on abdominal bruits in patients referred for hypertension to be of acceptably rigorous design. These reports were of sufficient size, applied uniform clinical assessment, and used angiography as the criterion standard (Turnbull, 1995). The results are summarized in Table 18.6. Not surprisingly, requiring a diastolic component makes the finding less sensitive but more specific than a bruit that may be heard only in systole. A diastolic component is more common in fibrous disease than in atherosclerosis and is correlated with a favorable surgical result (Eipper et al., 1976).

In one study (Moser and Caldwell, 1962), the bruit localized the lesion to the correct side in only 46% of patients with unilateral disease. In another study, the site of the renovascular lesion was

TABLE **18.5** *Prevalence of anterior abdominal bruits (in percentages)*

Reference	Normotensive	Hypertension (not renal vascular)	Renal vascular hypertension	
			Atherosclerotic	Fibromuscular
Hocken (1966)		7		
Shapiro et al. (1969)			43[a]	
Julius and Stewart (1967)	16	28	64[a]	
Grim et al. (1979)	0	1	39[a]	
Hunt et al. (1969)			36	80
Simon et al. (1972)				
Epigastric	6	38	55	
Flank	1	8	20	
Eipper et al. (1976)			35	76

[a]Types not distinguished.

TABLE **18.6** *Accuracy of the abdominal bruit in renovascular hypertension*

Reference	Type of bruit	Sensitivity	Specificity	LR, if present	LR, if absent
Grim et al. (1979)	Systolic–diastolic abdominal bruit	25/64 = 39%	197/199 = 99%	39	0.6
Fenton et al. (1966)	Any epigastric or flank bruit, including isolated systolic bruit	17/27 = 63%	82/91 = 90%	6.4	0.4
Perloff et al. (1961)	Systolic bruit	77.7%	63.6%	2.1	0.35

From Turnbull JM. Is listening for abdominal bruits useful in the evaluation of hypertension? *JAMA*. 1995;274:1299–1301, with permission.

correctly localized in 70% of patients with fibromuscular disease and 43% of patients with atherosclerotic disease (Eipper et al., 1976).

False positives may result from hepatic and splenic diseases (*vide infra*) and arteriovenous communications within the kidney (Hunt et al., 1969), either congenital, acquired (e.g., in a hypernephroma), or iatrogenic (e.g., after an unfortunate renal biopsy) (Clain et al., 1966).

Venous hums should not entrap the wary (see Chapter 19).

Self-study. Given a hypertensive patient from the general population of hypertensives (as opposed to the population referred to specialty clinics), in which the prevalence of renovascular hypertension is assumed to be 2%, what is the positive PV of a systolic–diastolic bruit? The PV of the absence of such a bruit? (The answer is in Appendix 18.3.)

Characteristics of Bruits Due to Renal Artery Disease

True renal vascular bruits tend to be asymmetric in their "radiation" over the anterior abdominal surface although again bilateral renal artery disease can produce a central abdominal murmur that "radiates" equally well into both flanks. But the point is that it does radiate into the flanks, whereas the "normal" aortic bruits tend not to radiate more than a hand's width from the midline on either side.

Renal artery stenosis murmurs tend to be more high pitched and shrill than the rushing murmur produced by an atheromatous plaque in the aorta or a stethoscopic compression of the aorta. Just as the trumpet makes higher notes than the wider-bored trombone, so does the renal artery stenosis murmur produce chords that are higher pitched (in the register of stethoscopic tonality) than does the wider-bored aorta. Bruits due to renovascular disease were high pitched in 64% (Julius and Stewart, 1967) to 87% (Moser and Caldwell, 1962) of cases.

Semeiophysiology of Diastolic Renal Artery Bruits

The semeiophysiology of these diastolic murmurs is uncertain. A possible explanation was offered by a very interesting patient:

A man who was said to have right-sided renovascular hypertension, as demonstrated by prior arteriography, was presented without the benefit of old records (always a mistake). On physical examination in a noisy room (also a mistake), an anterior abdominal bruit that radiated to the "wrong" (left) side was noticed. Furthermore, this bruit had the high-pitched musical tones that are highly diagnostic of renal artery stenosis.

Because this abdominal bruit had not previously been noted, the next morning the patient was reexamined in a quiet room. The same murmur was heard on the left, but in addition, there was a softer systolic murmur, radiating to the right, with a diastolic component (on the right, but not on the left).

The explanation became apparent when the old records were finally recovered. The patient had a left renal artery stenosis but also a complete occlusion of the right renal artery, possibly accounting for the discharge misdiagnosis of "right renal artery stenosis." Furthermore, the angiographer noted rich collateralization of the right but not the left kidney. Apparently, the flow in the collaterals produced the systolic–diastolic murmur.

Epigastric Bruits Heard in Normal Persons

The prevalence of systolic epigastric murmurs (excluding radiating heart murmurs) in normal (nonhypertensive) persons was found to be from 6.5% to 18% in three different series (Edwards et al., 1970; Julius and Stewart, 1967; Rivin, 1972). These murmurs were found to be more common in younger age groups.

Epigastric murmurs have been produced by increased blood flow in febrile adults (McSherry, 1979) or in children with acute infectious gastrointestinal disease (Lee, 1967).

Special populations have other prevalences: 21% of pregnant women (McSherry, 1979), 10% to 20% of "thin women of childbearing age" (Mohun, 1976), 25% to 26% of Canadian women of childbearing age (McSherry, 1979), 20% of women but only 3% of men although higher in the younger ages for both groups (Julius and Stewart, 1967; McSherry, 1979), 27% of gastroenterology outpatients (Watson and Williams, 1973), and 31% of psychiatric inpatients (Watson and Williams, 1973).

It is to be hoped that none of these figures are contaminated by including murmurs radiating from the heart or produced by the overly exuberant application of the stethoscope to a normal vessel.

Abnormal Epigastric Murmurs from the Aorta and Its Branches

Systolic epigastric bruits have been reported in diseases of the aorta (Clain et al., 1966; Rivin, 1972), including aneurysms (*vide supra*). They are also found in 90% of cases of stenosis of branches of the aorta such as the celiac axis and the superior mesenteric artery (Rob, 1966).

This raises the issue of the syndrome of external celiac axis compression, either by a fibrotic celiac ganglion or by the median arcuate ligament of the diaphragm, producing gastrointestinal pain that is relieved by surgery. (Some very experienced angiographers, such as Klaus Bron of Pennsylvania, do not believe that this syndrome exists because the same lesion may be seen in persons without symptoms.) Some believe that the murmur characteristically extends into early diastole (although it is not continuous) (Watson et al., 1973). However, as many as 14% of patients in one series did not have this murmur (Ghosh et al., 1982), and a small proportion of normal persons (0% to 1%) may have such a diastolic continuation of their innocent systolic murmurs (Grim et al., 1979). Others believe that the murmur is characterized by its disappearance or diminution on inspiration (Ghosh et al., 1982), but this does not always occur. Also, some believe that such respiratory change is actually characteristic of an innocent murmur (Watson et al., 1973).

An epigastric systolic bruit that shifts downward in location when the patient assumes the standing position should suggest an aneurysm in the freely movable omentum, which in one case was found to be in the gastroepiploic artery (Hatano et al., 1980).

An epigastric bruit with a diastolic component warrants investigation, in the proper clinical setting, because it could signal chronic intestinal ischemia. This condition may present with a variety of nonspecific symptoms and may be fatal if not recognized and treated. Most patients with this condition are believed to have an epigastric bruit. Phonoangiography may uncover a diastolic component (Sarr et al., 1980).

The loudest continuous epigastric bruits are heard in aortovenous fistulas, such as those involving the renal veins (Celoria et al., 1987), the iliac veins, or the inferior vena cava (Magee and Mellick, 1977).

Right–Upper-quadrant Murmurs

When not caused by renal vascular disease or tricuspid regurgitation, which may produce a bruit heard at the liver, right–upper-quadrant murmurs are from the liver or its vessels.

Specifically, a systolic murmur is heard in 14% of hepatomas (Benner and Labby, 1961), other primary malignant tumors, metastatic liver tumors (Sherman and Hardison, 1979), occasionally a benign liver tumor such as an adult hemangioma or a childhood hemangioendothelioma (Smith et al., 1978), and cirrhosis either with alcoholic hepatitis (Clain et al., 1966) or portocaval shunt (Goldstein, 1968). Arteriovenous malformations and 80% of posttraumatic arterioportal fistulas also have systolic bruits in this location (Strodel et al., 1987).

Murmurs heard only over the left lobe of the liver, which decrease with standing or in the lateral decubitus position, are more properly called *epigastric bruits*. Although they may be found with cirrhosis or neoplastic disease, they are thought to actually represent aortic compression by an enlarged liver (Sherman and Hardison, 1979).

Continuous murmurs in the right upper quadrant may originate from the right renal artery, the kidney, or the liver.

Causes of continuous bruits originating in the liver include cirrhosis (McFadzean and Gray, 1953), alcoholic hepatitis (Clain et al., 1966), 45% of hepatomas (Kingston et al., 1985), hepatic Hodgkin disease (Jones et al., 1978), hepatic arteriovenous malformations and shunts (McFadzean and Gray, 1953; Shumacker and Waldhausen, 1961), and posttraumatic arterioportal fistulas (Strodel et al., 1987).

Left–Upper-quadrant Murmurs

When not caused by renal vascular disease, left–upper-quadrant murmurs are a sign of disease of the spleen or its vessels, especially the splenic artery.

A splenic murmur can be produced simply from massive (grade 4 or better) splenomegaly (Bjorkman, 1953). The splenic artery can have a murmur if there is dissection (Serebro, 1965) or tortuosity (Smythe and Gibson, 1963), or it can have a murmur in the 39% of the cases of carcinoma of the body or tail of the pancreas in which the tumor actually impinges on the splenic artery (Bauerlein and de la Vega, 1963; Serebro, 1965).

A continuous murmur may be caused by a splenic arteriovenous fistula (occurring in about one third of cases) (Bloom, 1950) or by grade 4 to 5 splenomegaly (see Chapter 20) (Cassel et al., 1957; Williams et al., 1980).

Posterior Renal Artery Bruits

A Method

Using the diaphragm of the stethoscope, listen over the areas indicated in Fig. 18-6.

Interpretation

Posterior renal artery bruits are almost always systolic. Continuous posterior bruits, while rarely attributable to renal vascular hypertension, can also result from the same causes as anterior continuous bruits (*vide supra*). The sensitivity of any kind of posterior bruit for the diagnosis of renal vascular disease is 9% to 12% (Kaplan, 1986; Shapiro et al., 1969).

The false-positive rate is close to zero. I am personally unaware of any posterior murmur, systolic or continuous, that was truly "innocent." There is always an abnormal structural cause. When there is a posterior bruit not due to renal vascular disease, it is often continuous, has diastolic continuation, is louder anteriorly, or has an unusual location. Such tip-offs result in the PV of a positive test being close to 100%.

In summary, this sign is reliable if present but meaningless if absent.

This murmur becomes important in bilateral renal vascular diseases such as fibromuscular hyperplasia (in premenopausal women) or in atheromatous renal vascular disease (as in older men), especially when one is using screening tests, such as the rapid-sequence intravenous pyelogram, which compares the function between the two sides. Such tests are much less useful in bilateral renal vascular disease, as there is no "control" side, but knowing that the patient has bilateral posterior bruits may permit the clinician to skip such screening tests and proceed directly to arteriography.

Arteries of the Lower Extremities

Femoral Artery

Palpation

1. With the patient lying supine, his legs perfectly extended at the hips, place your fingers above the inguinal ligament about halfway across the thigh where it joins the torso. Push down with

the same force as used to insert a clove of garlic into a leg of lamb. The pulsation is the femoral artery. Note that as with all arteries, there is some anatomic variation. In some persons, it may be easier to feel it below the inguinal ligament.
2. Sometimes the femoral arteries are more medial and sometimes they are more lateral, but they are normally symmetric. To take advantage of this, try feeling for both at once. When you find one, you will know where the other should be. This method is particularly useful in older persons who may have inequality of the pulsation's intensity because of vascular disease.
3. The femoral artery is medial to the femoral nerve but lateral to the vein. If an attempted femoral artery puncture has produced radiating pain or venous blood, the location of the stick mark can be a useful future guide.

As noted above, the peak of the femoral pulse contour should arrive before that of the radial pulse.

Auscultation and Dynamic Auscultation

Be sure to auscultate for bruits. If aortic insufficiency is suspected, check for the Duroziez sign (see Chapter 17).

Bruits over the femoral triangle or the anteromedial thigh may be augmented with exercise, and they may develop a diastolic component. Carter's protocol for regional exercise involves auscultating with the patient supine, before and after full flexion and extension of the ankle at a rate of 1 cycle per second for 1 to 2 minutes (Kurtz, 1984).

The bruit–occlusion test is useful for localizing a stenosis when a bruit is heard over the common femoral artery in the inguinal region. After initial auscultation at rest, the examiner compresses the superficial femoral artery near the apex of the femoral triangle. If the observed bruit disappears or decreases in intensity, a stenosis is presumed to be present in the common femoral artery or proximal superficial femoral artery. In contrast, if the bruit does not change or becomes louder, the stenosis may reside in the profunda femoris or another branch vessel. In patients with a femoropopliteal bypass graft, impending occlusion can be suspected if compression causes the bruit to decrease or disappear, whereas an increase in bruit intensity suggests a lesion in the profunda femoris.

Complete disappearance of a distal bruit with proximal arterial compression almost always indicates stenosis in the compressed vessel (Kurtz, 1984).

The presence of a femoral bruit is a strong indicator of disease (LR 4.7 to 5.7), but the sensitivity is only 0.20 to 0.29. Thus, the LR, if the finding is negative, is close to 1.0 (0.7 to 0.8), and the absence of a bruit does not significantly change the probability of disease (McGee and Boyko, 1998). However, the absence of any bruit over iliac, femoral, or popliteal arteries in a symptomatic patient lowers the likelihood of peripheral arterial disease (LR 0.39) (Khan et al., 2006).

Popliteal Artery Palpation

A Method

1. Lean over the supine patient and put your hands on the sides of the knee, tucking your fingers into the popliteal space.
2. As you palpate for the vessel, lift the patient's knee, passively flexing it.
3. Move the knee no more than 10 degrees at a time, stopping to palpate for the popliteal artery.
4. If you get to 90 degrees of flexion and still cannot palpate the popliteal artery, stop and repeat on the other side.

Interpretation. If both popliteal arteries are impalpable and you have never examined the patient before, the findings are probably uninterpretable.

If the popliteal pulsation was previously symmetric and is now asymmetric or absent on one side, you have identified an occlusion of onset more recent than the previous examination.

If only one popliteal artery pulsation is present in a patient not previously examined, you have identified an occlusion of unknown duration.

If both popliteal arteries are impalpable and were present the last time you examined the patient, something has changed. The change may be as inconsequential as an alteration in pulse pressure or as major as a saddle embolus (which will also cause a diminution in the other lower-extremity pulses).

Skin Temperature

1. When examining a patient with symptoms suggestive of ischemia, do not forget to feel the skin over the symptomatic area. (I use the dorsal surfaces of my fingers.) Coldness is a classic, but insensitive, sign of chronic arterial insufficiency. It is more common in acute arterial insufficiency, a condition that will attract the clinician's attention in other, more dramatic ways. In a symptomatic patient, cool skin is the most useful physical finding (LR 5.90) (Khan et al., 2006).
2. In chronic arterial insufficiency, with claudication, you should also compare the skin temperature of the asymptomatic knee. In unilateral popliteal disease, the symptomatic knee may be warmer, not cooler. This paradox is explained by the fact that there are arterial anastomoses around the knee, close to the surface.

To avoid false positives, the sign should be sought after the limbs have been exposed to room temperature for at least 10 minutes. The presence of the sign implies that the main arterial flow is patent distally; otherwise, good collateral flow could not have developed (Gaylis, 1966). In distinguishing femoral (high) from popliteal (low) obstruction, this test had a sensitivity of 55% and 0% false positives (Zweifler, 1965).

Checking Blood Pressure at the Popliteal Artery

If you wish to take the lower-extremity blood pressure at the popliteal artery, you will need a thigh cuff. After attaching the thigh cuff, roll the patient into the prone position and passively flex the knee to 90 degrees. Place your stethoscope in the popliteal space over the area where the artery is or should be auscultable.

Posterior Tibial and Dorsalis Pedis Arteries

Palpation

A Pair of Methods

1. Using your right hand for the patient's right ankle and left hand for the patient's left ankle, place your first two fingertips beneath and behind the medial malleolus to palpate the posterior tibial

artery. "Beneath and behind" means in the posterior inferior quadrant, which is from 3 o'clock to 6 o'clock on the right ankle and from 6 o'clock to 9 o'clock on the left.

Question: *How far out does one need to go from the center of the malleolus to find the artery?*

Answer: *In most patients, the artery occurs at the point where one can begin to feel muscle above the bone.*

Some students find it easier to feel the pulse if they compress the tissues by pushing with the fingers of the other hand from the lateral side toward the palpating fingers.

2. Palpating the dorsalis pedis can be difficult because it is not always located where it was in anatomy class. To find an aberrantly placed dorsalis pedis pulse, place all four fingers, held together in a transverse picket line, about halfway down the lateral dorsum of the foot. Press lightly at first, then more deeply. If you do not feel a pulsation, edge your way medially. If your picket line does not find the dorsalis pedis, move it one finger-breadth distally and repeat. Then, if needed, move it one finger-breadth proximally from the initial position until all of the central portion of the dorsal foot has been covered. Slight dorsiflexion of the foot may make the pulse easier to find.

Teaching Trick

Find a conscious patient whose pedal pulsations are inapparent to you but apparent to someone else. Both of you should examine the patient at the same time, asking the patient to describe the differences in palpatory technique. For example, are you both searching in the same spot? Are you pressing harder or softer than the other examiner?

Some students are deceived into thinking they are feeling the patient's pulse when they are in reality feeling the pulse in their own fingertips. Use your other hand to check your own radial pulse to ensure that it is not simultaneous with the pulse you are attributing to the patient.

Congenital Absence of Pulses

A study of 1,000 children between the ages of 1 and 10, who presumably had not yet had the opportunity to develop obliterative atherosclerotic disease, revealed that all had posterior tibial pulses but that dorsalis pedis pulses were absent on the right in 3%, on the left in 3.7%, and bilaterally in 5.3%. One or both dorsalis pedis pulses were missing in 12.9% of whites as compared to 3.8% of blacks (Barnhorst and Earner, 1968).

My (remembered) experience with adults suggests that the figure (0%) for the absence of posterior tibial pulses is a bit low and that for the dorsalis pedis pulses is a bit high. (Testing this would make a nice student project.)

Some workers have tried to improve on the rules given above by feeling for the anterior tibial and the peroneal arteries. The former is located anteriorly, midway between the two malleoli, just above the ankle joint. The latter is 1 cm anterior and medial to the lateral malleolus. Either of these may substitute for the dorsalis pedis. However, the absence of the posterior tibial pulsations is still a problem.

Special Maneuvers for Diagnosing Arterial Insufficiency

The DeWeese Test

An exercise test can be extremely helpful in distinguishing between vascular and neurogenic claudication in a patient who has palpable pedal pulses at rest (DeWeese, 1960). Have the patient exercise, as by running in place, doing toe stands, or repeatedly flexing his ankle against resistance, to the point of symptomatic claudication. Disappearance of the pedal pulses confirms the presence of significant vascular disease, usually sufficient to produce vasculogenic claudication (W.D. Jordan, *personal communication*, 1998). If pulses are maintained, consider a *cauda equina* problem due to spinal stenosis (Hall, 1983). Owing to vasodilation, note that systolic blood pressure at the ankle declines with exercise even in individuals without occlusive arterial disease (Barner et al., 1968).

Other features that suggest spinal stenosis include worsening of symptoms with extension of the spine as in standing, relief with flexion as in sitting, and day-to-day variation in severity greater than that seen with vascular insufficiency (McGee and Boyko, 1998).

Ankle–Brachial Systolic Pressure Index

ABI measurement is obtained by measuring the highest systolic pressure at the ankle (dorsalis pedis or posterior tibial artery) and dividing it by the blood pressure in the arm. (These days, this is most conveniently done with a Doppler flowmeter if one is available.) Patients with symptoms of exercise-induced ischemia in the thigh, hip, or buttocks will have segmental hypotension—that is, blood pressure in the postobstructive arterial segment that is significantly lower than that obtained from the presumably nonobstructed brachial artery. (Note that indirectly determined blood pressures at the popliteal or dorsalis pedis are normally up to 10 or even 20 mm Hg higher than in the arm; see Chapter 6.)

Remember Meador's Rule. Patients with disease, sometimes at limb-threatening levels (ABI < 0.5), might still have a palpable dorsalis pedis pulse.

In patients with exercise-induced ischemia (but no ischemia at rest), the ABI is usually 0.5 or higher, and the resting dorsalis pedis blood pressure is generally greater than 60 mm Hg (Mannick, 1983). In patients with rest ischemia, the ABI is 0.4 or less and the dorsalis pedis blood pressure is generally less than 60 mm Hg. Determining the ABI is more diagnostic than listening for bruits. A low ABI predicts a significant decline in function over 2 years even in patients without symptoms (McDermott et al., 2004). An ABI <0.9 has a 95% sensitivity for detecting peripheral arterial disease compared with angiography (Khan et al., 2006).

As with the simple DeWeese test described above, there is no reason why one cannot improve upon the test by inducing a stress on the system (i.e., a more significant gradient can be elicited by inducing segmental hypotension in the symptomatic region, using vigorous muscular exercise to create a demand for an increased blood flow).

The ABI can be falsely high in patients with calcified, noncompressible distal arteries despite the presence of significant disease.

The Visual Flush Method

To estimate the blood pressure when Doppler equipment is unavailable, place the blood pressure cuff around the patient's ankle and elevate his foot. Inflate the cuff and return the limb to the horizontal position. Decrease the cuff pressure slowly, by 5 mm Hg every 10 seconds. The first appearance of a pink flush on the sole of the foot indicates the systolic pressure. In one study, 85% of the ABIs by this method were within 0.1 of the conventional ABI (Carter, 1968).

The Buerger Test

Another marker of arterial insufficiency is the Buerger test. Elevate the recumbent patient's legs perpendicular to the horizontal plane (defined as 180 degrees) above his head. This will cause foot pallor in those with vascular insufficiency. This is best seen when the disease is unilateral (the other side serving as a control) and in bright sunlight. Next, lower the leg slowly to determine the "angle of circulatory sufficiency"—that is, the angle at which the reddish hue returns. As the examining table surface would be 90 degrees, below the table surface would be less than 90 degrees and dangled perpendicular to the table would be 0 degrees (McGee and Boyko, 1998).

A variant of this test would be to elevate the patient's leg 60 degrees above the table (to 150 degrees by Buerger measurements) for 2 minutes and then dangle the leg over the edge of the table (0 degrees) for 2 minutes. A positive test is foot pallor with elevation and the appearance of a dusky red flush spreading proximally from the toes in a dependent position (Insall et al., 1989).

Venous Filling Time

After placing the patient in a supine position, identify a prominent pedal vein. Lift the patient's leg 45 degrees above the table for 1 minute. Have the patient sit up and dangle the legs over the side of the examining table. Record the time in seconds until the previously identified vein rises above the level of the skin surface. A time of greater than 20 seconds had a sensitivity of 0.22 to 0.25 and a specificity of 0.94 to 0.95 for presence of disease defined as an ABI less than 0.5 (Boyko et al., 1997).

Capillary Refill and Other Tests

The capillary refill test and findings of foot discoloration, atrophic skin, and hairless extremities are not helpful in making diagnostic decisions concerning peripheral vascular disease (McGee and Boyko, 1998). The first has been shown to be unreliable because blood expressed by the examiner's finger can return from adjacent veins even in a limb experimentally rendered completely ischemic.

In young children, however, the capillary refill test is the most useful individual sign for detecting dehydration of 5% or more, with a positive LR of 4.1. A standardized way to administer the test is to gradually apply pressure to the palmar side of a distal fingertip held at the level of the heart, and then release it immediately when the capillary bed blanches. In a nondehydrated child, normal color should be restored in less than 1.5 to 2 seconds. Be sure that the ambient temperature is warm (Steiner et al., 2004).

Pedagogic Inspiration

In one study, attending vascular surgeons compared themselves with house staff and students in their ability to diagnose peripheral occlusive disease. Each was allowed to take a history and to palpate the abdominal aorta, the femoral, popliteal, dorsalis pedis, and posterior tibial pulses and to use an ordinary stethoscope. If after an examination at rest, there still was some question as to the patient's anatomic lesions, the patient was exercised to tolerance and the examination repeated. In 102 patients, the surgeons made an anatomically correct diagnosis (as verified by the vascular laboratory) in 96% and were partly correct in the other 4%. Their younger colleagues were totally correct in 62%, partly correct in 35%, and totally wrong in 3%. Noninvasive laboratory tests were much better than the younger physicians but not quite as good as the attendings (Baker et al., 1978). These results suggest that performance improves with experience, a conclusion that will not be surprising to athletes and musicians. They may also explain the younger generation's rush to the laboratory.

Microvasculature

There are only two parts of the body where the microvasculature can be visualized at the bedside. One is in the nail fold (see Chapter 7) and the other is in the fundus oculi (see Chapter 10).

Peripheral Perfusion and Shock

As Hippocrates noted, "It is a bad symptom when the head, hands, and feet are cold" (Adams, 1849). Seasoned cardiovascular clinicians place their hands on a foot on arrival at the bedside of a pediatric patient who has had cardiac surgery. Cool extremities, along with a slight increase in heart rate, decrease in urine output, and unexplained anxiety or irritability, are early signs of compensated shock (Fagan, 1988). Early measurement of toe temperature using a thermistor probe taped to the great toe correctly predicted the outcome of adult patients admitted to a Shock Research Unit 67% of the time. These patients had an acute life-threatening respiratory, circulatory, or metabolic defect such as myocardial infarction, sepsis, blood loss, or drug overdose (Joly and Weil, 1969).

Toe temperature is less useful in adults because of the increased likelihood of peripheral vascular problems as a confounding variable (R.S. Farmer, *personal communication*, 2004).

Other Vascular Conditions

Mycotic Aneurysms

In the term *mycotic aneurysm*, first described and named by Osler, "mycotic" refers not to the infectious agent (because few are fungal; most are bacterial) but to the fact that the infected

aneurysm appeared to Osler to be in the shape of a mushroom. The only good clue is petechial seeding of the area supplied by the infected vessel.

Dr David Dobmeyer of Missouri once asked me to see a patient who was septic and thought to be suffering from endocarditis. His petechial rash was peculiar in that it afflicted one lower extremity almost exclusively. Knowing that the patient had previously received shrapnel wounds high in that extremity, I raised the possibility of an infected aneurysm. This produced much risibility until 6 days later when the march of the imaging procedures suggested the very same diagnosis, which was indeed confirmed at curative surgery. There never was any endocarditis.

Arteriovenous Fistulas

If the arteriovenous fistula is observable, one can palpate the thrill and auscultate the murmur. In some fistulas that are not accessible to direct inspection, palpation, or auscultation, the Branham sign may be performed (see Chapter 6).

Suspect an arteriovenous fistula in patients with a high cardiac output state, a hypertrophied limb, or a pulsatile mass, especially if any of these occur after trauma.

Appendix 18.1

Answer to Question on Page 386

The aorta has a wider diameter than the peripheral vessels and both experience the same pressure. Therefore, aortic wall tension should be higher and aneurysms should form there first. By the time peripheral vessel aneurysms appear, the aorta has a good chance of one of its aneurysms already having grown to noticeable size.

Appendix 18.2

Discussion of Case Report

The most common reason for missing a ruptured abdominal aortic aneurysm, according to Dr Christopher Compton of Tucson, Arizona, is failure to place a hand on the belly. When a patient's normally high blood pressure is suddenly normal or low, this is not necessarily a therapeutic effect from his antihypertensives. Apparently, no one asked why the patient's wife decided to accompany him for the first time or why he was using a walker. A physical examination might have shown pale conjunctivae, tachycardia, an orthostatic blood pressure drop, and diminished pulses in the legs, as well as the aneurysm.

The patient survived the operation to repair his aneurysm, but succumbed to complications some weeks later.

Aneurysms can leak for some time before a catastrophic rupture and can cause radiated pain.

Appendix 18.3

Answer to Self-study on Page 389

In a population of 1,000 patients from the general population of hypertensives, 20 will have renovascular hypertension and 980 will not. Given a sensitivity of 39%, 7.8 of the patients with renovascular hypertension will have a systolic–diastolic bruit (true positives) and 12.2 will not (false negatives). Given a specificity of 99%, 970.2 of the patients without renovascular hypertension will lack a systolic–diastolic bruit (true negatives), while 9.8 patients will have one (false positives). Thus, the PV of a positive test is 44% and the PV of a negative test is 99%. Verify these answers by looking at Fig. 1-3, noting that the prior probability is 0.02 or 2% and that the LR is 39 if the finding is present and 0.6 if it is absent.

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Weiss S, Baker JP. The carotid sinus reflex in health and disease: Its role in the causation of fainting and convulsions. *Medicine*. 1933;12:298–353. [Soma Weiss taught the author's teacher, Jack Myers. Because the author is now teaching you, you are Soma Weiss's medical great-grandchild. Probably, you could get back to any of the others in this bibliography, even to Hippocrates, through more circuitous genealogies, if records were available. The point is that a great tradition is now presented to you in your turn.]

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CHAPTER

19

Veins

All the blood is under the jurisdiction of the heart. The twelve blood vessels are deeply hidden between the muscles and cannot be seen. Only those on the outer ankles are visible because there is nothing to cover them in these places. All other blood vessels that are on the surface of the body are veins. The harmful effects of wind and rain enter the system first through the skin, being then conveyed to the capillaries. When these are full, the blood goes to the veins and these in turn empty into the big vessels. The blood current flows continuously in a circle and never stops.

—*Chinese Classic of Internal Medicine*, 2,000 years before William Harvey (Hume, 1930)

Points to Remember:

- To distinguish prominent neck veins from those distended because of increased central venous pressure, ascertain whether the veins fill from below.
- If you can see fluttering waves in inspiration and expiration, you can be sure that you are looking at the top of the venous column.
- Elevated venous pressure can also be discerned from looking at hand veins or sublingual veins, especially in ICU patients when one cannot get an unobstructed view of the neck veins.
- From the neck veins, estimate the venous pressure; determine the effect of inspiration (Kussmaul sign) and of pressure on the abdomen (abdominojugular test, also called hepatojugular reflux), and observe the venous pressure waves.
- Always have a high index of suspicion for deep venous thrombosis, especially in patients with any feature of the Virchow triad of vein wall damage, stasis, and hypercoagulability.

Venous Pressure

A Method: Inspecting the Neck Veins

1. Begin with the patient relaxing comfortably in bed with the head of the bed elevated between 30 and 45 degrees.
2. There are two different jugular veins (Fig. 19-1). The *internal* jugular[1] vein is posterior and superior to the medial fourth of the clavicle, running cephalad until it passes under the sternocleidomastoid muscle. (Right above the clavicle, one is actually looking at the inferior jugular bulb, which lies between the clavicular and sternal insertions of the sternocleidomastoid and is where this muscle splits into two heads.) The second vein is the *external* jugular, which crosses over the top of the sternocleidomastoid muscle. There are advantages to using each.

   Perloff considers the internal jugular to be the better vein for pressure estimation and waveform (venous pulsation) analysis. Although the vein itself is generally too deep to be seen, one often sees transmitted pulsations. With extremely high venous pressure, it may be difficult to move a sick patient to a position sufficiently erect to permit a clear view of the internal jugular vein collapse, which is how one determines the venous pressure (vide infra). The external jugular is less often inapparent when compared with the transmitted pulsations of the internal jugular vein and can, moreover, be seen for a longer distance. Therefore, it is more often usable in a bed-bound patient in whom the pressure is extremely high, especially when the internal jugular vein is too short to permit stripping it to be sure there is reflux from below (vide infra). When visible, the pulsations from the internal jugular should be more definitive (vide infra).

   I suggest that the neophyte try observing both pulsations. After you have examined 100 patients, you will know which method works for you.
3. If jugular venous pulsations cannot be seen, lower the top half of the bed until they appear. Be sure to check that both the left and the right external jugular veins distend at approximately the same degree of elevation during the same phase of respiration. If the left external jugular vein is selectively distended, this is a useful diagnostic clue to certain entities to be discussed below. Most use the right jugular veins to make measurements because they take a straighter path into the right atrium and yield less chance of interference with the waveform by ectatic arteries.
4. In some patients, the jugular veins are inapparent to the clinician even when actually full. To distinguish between inapparent veins and the absence of venous fullness ("distention") in a given patient, have the patient perform the Valsalva maneuver for about 10 seconds. This will temporarily increase venous pressure to an abnormal degree; if you still cannot see the jugular veins, then they are inapparent (Fig. 19-2, Valsalva panel). Thus, you can make no statement about venous pressure on the basis of the neck veins in this patient and will have to find another method of estimating it, as discussed later in this chapter.
5. If the veins appear to be spontaneously distended, you must next determine whether they represent the pressure from below or are simply prominent. To do this, strip the vein in the following manner:
   a. Place your adjacent forefingers over a distended segment of the external jugular vein. (The internal jugular vein or bulb

[1] Same as cervical.

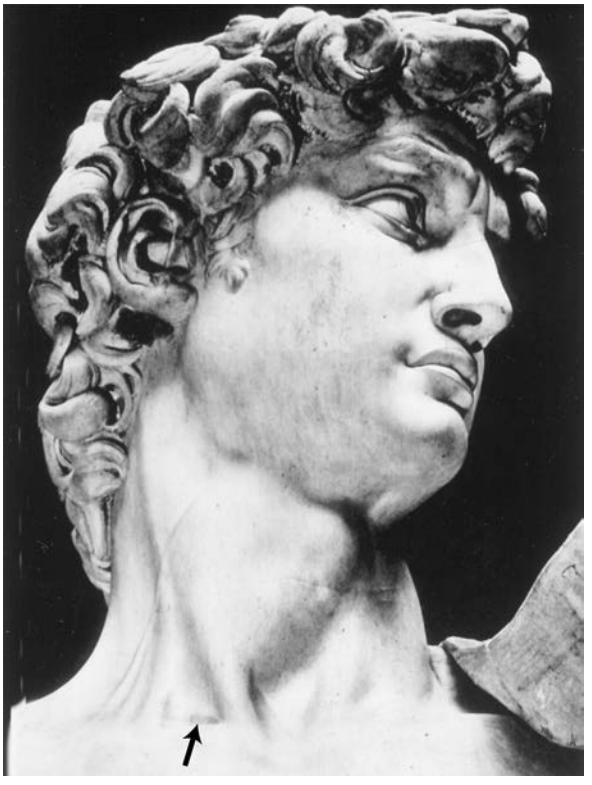

Figure 19-1 The external jugular vein is seen crossing the sternomastoid. The *arrow* marks the inferior jugular bulb, visible just above the clavicle between the two heads of the sternomastoid. (David, by Michelangelo.)

does not usually have a visible segment sufficiently long to permit these manipulations.)

b. Strip the vein of its blood by moving your fingers apart while maintaining firm pressure on the vein. The vein should now be flat as you maintain pressure on it with both fingers.

c. To test for "filling from below" (from the heart back up into the veins), release only the finger closest to the heart. Maintain the other finger in its place.

d. If the central venous pressure is high enough, the vein will fill in a retrograde fashion ("from below"). (Fig. 19-2, stripping panel.)

Of course, if the venous valves were perfectly competent, the vein would not fill in retrograde fashion, but the distention of any vein tends to impair coaptation of the venous valves, so this is almost never a problem.

6. Take the venous pressure measurement.

a. Look for the fluttering waves in inspiration or expiration. If you can see them, then you are looking at the top of the venous column, which is analogous to the meniscus in the venous pressure measurement manometer (*vide infra*). It is helpful to exaggerate the vein by shining a penlight on it obliquely so as to cast a shadow posteriorly on the neck. (This is especially useful for detecting pulsations.)

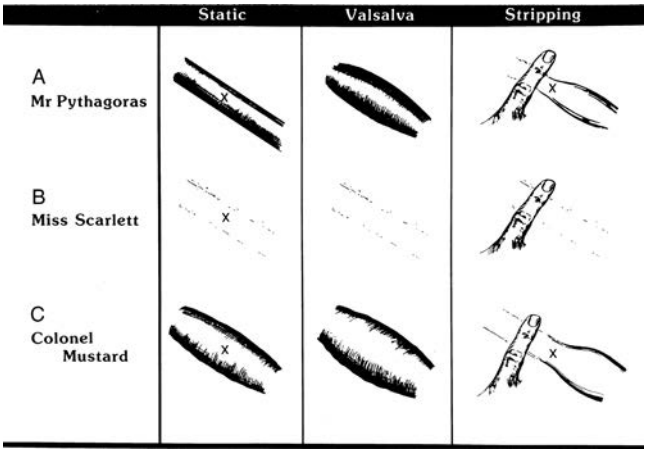

Figure 19-2 **A:** At the top left is shown a segment of Mr Pythagoras's external jugular vein as he is propped up at an angle in bed. Let "X" be a point on the vein that is 16 cm vertically above the center of the right atrium (see text). If the jugular venous pulsations (the theoretical meniscus) are seen higher than this point, then Mr Pythagoras would have an elevated venous pressure even if his veins did not appear to be "distended." **Valsalva panel:** This shows Mr Pythagoras's right external jugular vein during the Valsalva maneuver. It is now distended. On the basis of this panel alone, one cannot determine whether Mr Pythagoras has an elevated venous pressure when he is not doing the Valsalva maneuver. The panel simply shows that his external jugular vein can be easily demonstrated. **Stripping panel:** If the pressure in the lower segment backfills the vein to a point "X" that is more than 16 cm vertically above the center of the right atrium, the venous pressure is increased. (Of course, the vein above the occluding finger will become distended [not shown], and if that finger is removed, the vein will be seen to fill from above, confirming that the blood in the veins flows from the head toward the heart, a fact that is already known. See chapter epigram) **B:** Miss Scarlett is a refined princess who has done no physical work in her life and therefore has an underdeveloped venous system. Thus, her external jugular vein is all but inapparent. "X" is a point about 16 cm vertically above the center of her right atrium, but by simple inspection of this point, it is not possible to determine whether her venous pressure is elevated or normal. **Valsalva panel:** A sustained Valsalva maneuver can generate venous pressures greater than 30 cm of water, but even with this excess of intravenous pressure, no distention of Miss Scarlett's pristine jugular venous system is seen! Thus, in this particular patient, the absence of "jugular venous distention" means absolutely nothing! Specifically, it cannot be used as evidence against congestive heart failure or other causes of elevated systemic venous pressure. **Stripping panel:** The stripping maneuver shows no backfill because there is insufficient venous development. In fact, were the panel to illustrate release of the superior finger, it would look the same. Miss Scarlett's veins are simply inapparent no matter what the pressure. **C:** Colonel Mustard spent many years at physical labor in the colonies and has extremely well-developed jugular veins. But what is his true venous pressure? **Valsalva panel:** The expected increase in the jugular distention that is already present helps not at all and is shown only for completeness. **Stripping panel:** On stripping the vein and releasing the inferior finger, we can see backfill to the point "X," where venous pulsations would also be seen. (The distention in the vein above the finger, which would eventually occur, is not shown and would not be searched for.) The flat segment of vein from the finger down to "X" is what guarantees that the correct venous pressure has been found. If "X" is less than 16 cm above the center of the right atrium, then the venous pressure is normal. Note that Colonel Mustard could have what is called "jugular venous distention" at rest (left-hand panel) even if his venous pressure were normal. Thus, the "finding" of "distention" means absolutely nothing.

b. In order to find the top of the column, it may be necessary to have the head of the bed elevated and depressed several times, repeating the stripping motion each time.
c. The venous pressure is estimated to be the *vertical distance* between the top of the blood column (the "fluttering") and the right atrium. (The angle of the patient and the distance along the vein do not matter.) With the patient supine, the right atrium (the zero reference point, i.e., the point at which the venous pressure is zero) is located in the fourth intercostal space about 35% to 50% of the distance from the sternum to the bed along the anterior–posterior diameter. (To verify this, look at a computed tomography [CT] scan if you have not had the opportunity to look at about 25 cadavers as we did years ago.) The upper limit of normal, by this method, is 16 cm. (For normal values obtained by using other zero reference points, see later in this chapter.)

Note. This is now a minority report, which differs from the current methods such as those using the angle of Louis as a zero reference point. The angle of Louis (the sternal angle) is supposed to be 5 cm above the center of the right atrium in all people and in all positions. I call this the *cardiologist's constant*.[2] This is obviously not the case (Figs. 19-3 and 19-4) despite the fact that in many prestigious textbooks (Braunwald et al., 2001) and recent

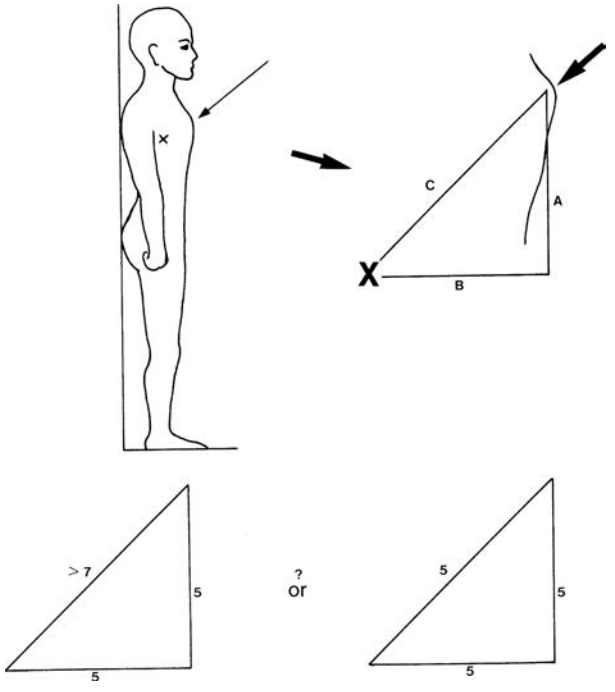

Figure 19-3 Pythagoras's angle of Louis is marked with an *arrow,* and the center of his right atrium is marked with an "X." An enlarged version of the area of interest is shown at the top right. If it is true that the angle of Louis is always 5 cm above the center of the right atrium, then side A of the triangle would be 5 cm with Pythagoras erect. By the same statement, side B of the triangle would be 5 cm with Pythagoras recumbent (turn the book on its side to see this), and side C would be 5 cm with Pythagoras at a 45-degree angle. This leads to the triangle shown at the bottom right, contradicting the theorem of Pythagoras ($A^2 + B^2 = C^2$) which would give the triangle at bottom left.

[2] It has also been given as 2.5, 8, and 10 cm.

Figure 19-4 Dan Koehler (98 in. tall), Mishu (32 in.), and David Frost (65 in.) represent the extremes and approximate mean of a Gaussian distribution. Would you expect the cardiologist's constant to be the same in all? (From the Guinness Book of World Records, published by Sterling Publishing Co, Inc., New York, copyright 1987 by Guinness Superlatives Ltd. Reprinted with permission.)

reviews (Cook and Simel, 1996) the cardiologist's constant seems to be as durable as Planck's constant. The differences between actual readings obtained from the two methods will be less than the margin of error, but sloppy thinking and imprecise language are contagious.

Validity

It is stated that the examination of the jugular veins is the most reliable means of clinical estimation of (peripheral) venous pressure "and actually often exceeds in accuracy the measurement of venous pressure with the saline manometer in inexpert hands" (Fowler, 1967). This statement is an interesting epistemologic pretzel knot: Assuming it is true, how would one know it (i.e., what would be the independent covariable to the other two)? The key word in Fowler's statement may be "inexpert," which is undefined. However, on the basis of a study involving independent and simultaneous measurement of the central venous pressure (Davison and

Cannon, 1974), two other interested observers concluded that the central venous pressure cannot be reliably estimated by inspection of the jugular veins. (Of course, the peripheral and central venous pressures cannot be exactly the same. Otherwise, blood would not flow.) Yet, 90% coincidence could be achieved in that study if one were willing to accept an error of up to 4 cm. Clinically, if one estimates a pressure of 24 cm of water, it does not matter very much whether it is truly 20 or 28 cm. Similarly, if one estimates a pressure of 8 or 10 cm of water, one can be confident that the true value is not above 16 cm (the upper limit of normal). Thus, although not perfect, such an estimation becomes one more brick in the Great Wall of diagnosis.

Other Nonmanometric Methods

1. Wiener and Nathanson (1976–1977) estimate the external jugular venous pressure with the patient supine. The vein is stripped and the meniscus observed after a *moderate inspiration*. They state that the meniscus in normal people is usually 3.5 cm below the angle of Louis. (Using the cardiologist's constant, this would give a "normal" pressure of 1.5 cm!) In a patient with very high venous pressure, it would not be possible to see the meniscus during inspiration. Thus, with this method, one could tell that the venous pressure was high but would not know how high. Therefore, do it right. (Elevate the head of the bed for such patients.)
2. In contemporary intensive care units, it is often difficult for the attending physician to get an unimpeded view of a jugular vein whose vascular connection to the right atrium has not been impeded by medical interventions. Accordingly, it is helpful to use a modification of the *Gärtner maneuver* (Dennison, 1969). This consists of raising and lowering the hand while stripping its veins until one finds a point of elevation at which they are no longer distended. One then slightly lowers the hand until the veins begin to distend; the vertical distance from this point down to the right atrium is the estimated venous pressure.

A Self-study

While seated or standing, place one hand as far above your head as possible and make a fist; leave your other hand hanging open at your side. After about 15 seconds, place both your hands in front of you and inspect them for color and vein distention. The hand that was elevated is paler and the veins are not distended; the dependent hand is darker and the veins are distended.

Repeat, reversing the hands.

Have your partner perform this while your eyes are closed. After both his hands are brought level, open your eyes and see whether you can determine which one had been elevated.

Historic Note

This is the basis of an old carnival confidence game. The con man is blindfolded or has his back turned while the "mark" (victim) holds a gambled coin in the clenched hand. The con man keeps guessing wrong at two-to-one odds and pays off until the "mark" gets greedy and raises the stakes.

3. Another method is the *von Recklinghausen maneuver*, in which a supine patient has one hand resting on the bed and one resting upon the thigh. If the veins are swollen in both hands, elevated venous pressure is diagnosed, but if only the veins in the lower hand are swollen, the venous pressure is said to be normal. Gärtner's method gives a continuously distributed measurement. But for those who like two-humped camels (see Chapter 16), von Recklinghausen's method may be preferable.
4. If the *sublingual* veins are distended with the patient in the sitting position, one can be certain that the venous pressure in this segment of the venous tree is elevated. The most common cause of such an elevation is congestive heart failure. However, there is no reason that this sign could not be positive in superior vena cava syndrome, constrictive pericarditis, or pericardial tamponade. Dr John DeGroote of Mississippi first persuaded me of the utility of this sign.

Manometric Determination of Peripheral Venous Pressure

History

In the 1950s, elevated venous pressure was sought by manometry in patients suspected of having congestive heart failure. The requisite venipuncture also provided the opportunity to perform a circulation time, which could separate high-output from low-output congestive failure, a distinction still useful although currently arrived at by other, more expensive, means.

In the 1960s, the peripheral venous pressure determination was abandoned because the central venous line was coming into widespread use. Cases of high-output cardiac failure were increasingly diagnosed at cardiac catheterization.

In the 1970s, the flow-directed balloon-tip (Swan–Ganz) catheter gave us the opportunity to determine left ventricular filling pressure. Despite the fact that this catheter had to be passed through all previously accessible venous compartments, potentially permitting measurement of central and peripheral venous pressures, such measures disappeared from medical center charts. Unfortunately for clinical examination, the left atrial filling pressure does not always correlate with the peripheral venous pressure as determined clinically. Although the external jugular venous pressure does correlate with the central venous pressure, this statistically significant correlation is felt by some to be clinically treacherous (Davison and Cannon, 1974). Thus, as our technology has become more sophisticated and much more expensive, it has become almost impossible for the medical student or house officer to determine the accuracy of his own clinical examination, which has usually deteriorated to the worse-than-useless statement that "the neck veins were (or were not) distended" (see legend to Fig. 19-2).

The death knell for the direct determination of the peripheral venous pressure came in the 1970s when third-party payers, such as Blue Cross and Blue Shield, refused to pay the $10 or $15 fee for the peripheral venous pressure (with or without a circulation time). Yet, these same carriers pay for the much more expensive determination of ejection fraction by radionuclide cardiography, which appears to be used in clinical practice in exactly the same way as the venous pressure and the circulation time.

Nevertheless, "hallowed techniques of physical diagnosis tend to rise Phoenix-like from their own ashes" (Snapper and Kahn, 1967). The expense of the radionuclide determinations may eventually be noticed by the bureaucrats who increasingly dictate the specifics of current medical care. The morbidity and mortality resulting from

epidemic use of the flow-directed balloon-tip (Swan–Ganz) catheter may prove to outweigh its marginal benefits (Angus and Black, 2001; Robin, 1985). A much cheaper and noninvasive set of measurements obtainable at the bedside from the M-mode echocardiogram (Askenazi et al., 1981) has been suggested as a method to supplant the Swan–Ganz for measuring left atrial pressure. (This new technique uses the echocardiographic equivalent of the S2-opening snap interval once used by bedside clinicians to determine the severity of mitral stenosis; see Chapter 17.) While controversy continues, almost 2 million Swan–Ganz catheters were sold in North America in 2003.

A Method

1. Place the supine patient's right arm on a pillow or towels so that the antecubital vein will be at the zero reference point.

   As noted above, the zero reference point used in this text is a point one third to one half the distance from the sternum down to the bed. Many other zero reference points have previously been offered; these are given in Table 19.1.

   Which one should be selected? As elsewhere in medicine, one prefers those that take account of the variability in body size and that permit an easy determination. That said, probably any one is satisfactory if you use it consistently and become familiar with its inherent reliability.
2. Insert a needle attached to a three-way stopcock and a manometer (the same apparatus that is used when performing puncture of the lumbar interspace for obtaining cerebrospinal fluid samples and pressures).
3. Via the third port of the stopcock, fill the manometer with sterile saline. Allow the saline to flow into the vein until the pressure equilibrates. Alternatively, use sterile 5% sodium citrate, an anticoagulant.
4. Read the equilibration point when the patient is not coughing, sneezing, or performing a Valsalva maneuver. Note that the pressure normally *drops* with inspiration. If it increases paradoxically, the patient has a positive Kussmaul sign for constrictive pericarditis (*vide infra*).
5. You may wish to perform the test for abdominojugular reflux at this point (*vide infra*). The advantage of doing this now is that the pressure is directly measured in the manometer, so if the hepatic compression causes an elevation of 3 cm in the venous pressure, it is easy to see irrespective of the patient's venous anatomy and position in bed (two factors that may complicate the inspection of the jugular veins).
6. Continue with the circulation time (Appendix 19.1).

Significance

Use the normal values corresponding to the zero reference point that you chose.

In general, the pressure in congestive heart failure is greater than 16 cm and is occasionally as high as 30 cm. The pressure may also be elevated with pericardial tamponade, tricuspid stenosis, superior vena cava syndrome, constrictive pericarditis, and restrictive cardiac disease.

"Jugular venous distention" (see definition in Table 19.3) is said to be a more accurate predictor of an elevated pulmonary capillary wedge pressure (PCWP) than is the presence of pulmonary rales: positive predictive values (PVs) are 67% versus 46%, respectively (Butman et al., 1993).

False Positives

The pressure may be elevated acutely if the patient is straining or, in obstructive lung disease, if an elevated intrapleural pressure is maintained through most of the respiratory cycle.

TABLE **19.1** *Zero reference points previously used for venous pressure measurements*

Authority	Normal venous pressure (cm)	Zero reference point
Moritz and Von Tabora	1–9	Right atrium as remembered
Taylor et al. (1930)	4–8	5 cm below the horizontal plane of the anterior surface of the sternum at its fourth costochondral junction
Friedberg (1956)	3–10	The point of Taylor et al. modified "depending on the approximate thickness of the chest wall"
Lyons et al. (1938)	5–15	10 cm above the level of the skin on the subject's back when the subject is recumbent
Hussey (1939)	4–12	The midaxillary line
Winsor and Burch (1946)	5–14	Half the distance from the base of xiphoid to the table (if the patient is tilted up at an angle, the point is half the distance to the patient's back along the fourth intercostal space)

From Friedberg CK. *Diseases of the Heart.* 2nd Ed. Philadelphia, PA: W. B. Saunders; 1956, with permission.

False Negatives

In *pure* acute left-sided ("backward") heart failure (prior to renal retention of sodium), the pressure may be normal.

The Kussmaul Sign

> Et spiritum tumore cohibente venarum.
>
> [And his inspirations engorged his veins.] (Ammianus Marcellinus, XXV 3, 23)
>
> (Death scene of Julian, who had been stabbed in the ribs by a Persian spear.)

Self-test (see answer in Appendix 19.2). Could this be the first description of the Kussmaul sign in pericardial tamponade? (Be careful, this is a curve ball.)

The Kussmaul sign is the inspiratory distention of the neck veins. It is probably one of the easiest of all physical signs to master, especially because it is the exact opposite of the normal expiratory distention of the cervical veins.

A Self-study

Simply look at your recumbent partner's neck veins and notice how the pressure drops during a strong inspiration. The pulsations are no longer seen. In some persons, even the vein's location may become inapparent.

Semeiophysiology

Inspiration generates a negative intrapleural pressure, which sucks the venous blood into the heart. But with constrictive pericarditis and some other diseases, there is sufficient impairment of right heart filling that the blood sucked into the chest cannot enter the heart and the venous pressure rises. In such patients, inspiration will cause a "paradoxical" rise in the venous pressure. At the bedside, this can be detected by inspection: the flutterings or vein filling are seen in inspiration but disappear in expiration (the veins go flat), the exact opposite of what you saw in your partner.

Significance

The Kussmaul sign is seen in constrictive pericarditis, some cases of endomyocardial restrictive disease (such as endocardial fibroelastosis), myocardial restrictive disease (such as amyloidosis), tricuspid stenosis, congestive failure (especially that called right sided), superior vena cava syndrome, and right ventricular infarction. But, contrary to what was formerly taught, it is never seen in uncomplicated pericardial tamponade (Table 19.2.) In fact, its appearance in the latter setting suggests the development of a constrictive or restrictive pericardial component and/or epimyocardial fibrosis. In pure tamponade, pericardial pressure and right atrial pressure are elevated but equal to each other. The inspiratory fall in intrathoracic pressure is transmitted to the pericardial space, and the normal inspiratory increase in systemic venous return is preserved so that the Kussmaul sign does not occur. The pericardial space is obliterated in constrictive pericarditis so that during inspiration the decreased intrathoracic pressure is not transmitted to the heart, venous pressure does not fall, and systemic venous return does not increase (Fuster et al., 2000).

The Abdominojugular Test (Hepatojugular Reflux)

History

William Pasteur first described what has been called *hepatojugular reflux* (Pasteur, 1885):

> In several cases in which there was reason to suspect functional incompetence of the tricuspid valve which have recently come under my observation, a physical sign has been present to which I believe attention has not been drawn, and of which I have been unable to find any mention either in the standard textbooks or in the best known monographs on the subject of cardiac disease.

TABLE **19.2** *Findings in some diseases of the right heart and pericardium*

	RV infarction (%) (Cintron et al., 1981)	Pure constrictive pericarditis[a] (Shabetai et al., 1970; Spodick, 1983)	Pure tamponade (large, acute effusion) (Reddy et al., 1982)
Kussmaul sign	30–100 (Cintron et al., 1981; Dell'Italia et al., 1983)[b]	33% (late, severe)	No
Pulsus paradoxus (see Chapter 6) (Reddy et al., 1982; Shabetai et al., 1970; Spodick, 1983)	71 (Lorell et al., 1979)[b] "none" (Dell'Italia et al., 1993)	No	>70%–100%
Y descent prominent	71[b]	33%	No

[a]Also see the Broadbent sign (Chapters 16 and 17).

[b]Or is it an X descent? (Goldstein, 1989). It has been suggested (Goldstein et al., 1990) that earlier workers could not tell the difference between the X and Y descents. The literature concerning right ventricular infarction is not consistent. The Kussmaul sign is variously stated to occur in 29% to 100% of patients, and pulsus paradoxus is stated to occur in "none" or "most" of the patients (Sapira, 1993).

RV, right ventricle.

> This sign consists in a distension—with or without pulsation—of the superficial veins of the neck, occurring when firm pressure is exerted over the liver in the direction of the spinal column, and independent of the movements of respiration. A little consideration of the anatomical relations of the parts concerned will suggest the facility with which an impediment may be created to the flow of blood, in either direction, through the vena cava inferior by such a maneuver, especially when the liver is obviously enlarged. It seems to me that the state thus produced is virtually that which obtains as a chronic condition in long-standing and severe cases of tricuspid incompetence as far as regards the tension in the systemic venous system in the immediate vicinity of the heart. Assuming the existence of tricuspid regurgitation and of a source of compression of the vena cava inferior, it is obvious that with each systole an excessive reflux of blood must take place into the vena cava superior and its tributary veins. It may be noted that the question of pulsation, as compared with distension or undulation, is merely one of degree of morbid venous tension. Although the number of cases in which I have observed this phenomenon is certainly limited, I have never failed to elicit it when there was indubitable evidence of tricuspid incompetence; on the other hand, I have hitherto invariably failed to obtain it in other forms of cardiac valvular disease, and in various cases of hepatic enlargement from causes other than passive congestion. I cannot but think that this sign may furnish an important aid to diagnosis in cases where the usual signs of tricuspid regurgitation are ill-developed or in abeyance, and that it may prove a valuable factor in the difficult general problem of prognosis in cases of cardiac disease.
>
> My chief object in making this short communication is to draw attention to a point which I believe to be of some importance, with a view to stimulate observation, and it may be to elicit further facts.

I cite this article for several reasons:

1. This is the entire article, requiring only two paragraphs and occupying less than one fourth of one page.
2. Pasteur was unable to obtain this sign in other forms of cardiac valvular disease, so he believed it to be diagnostic of tricuspid insufficiency. (Could it be possible that none of his other patients had heart failure? We should realize that even one of our best colleagues was capable of such a miss, illustrating the truth of Jean de la Bruyere's statement: "The exact contrary of what is generally believed is often the truth.")

The foundation for the modern concept of the hepatojugular reflux was built by Rondot in three papers in 1898. Rondot's clinical acuity may be judged from the fact that he sometimes noticed a muffling of the first heart sound to occur during the performance of the hepatojugular reflux. Today, we would say that this maneuver causes an abnormal elevation in the right atrial pressure, decreasing the early systolic pressure gradient between the right ventricle and right atrium and therefore decreasing dP/dt and making the sound of tricuspid closure softer than usual. In his day, Rondot could say only empirically that this change pointed toward disease of the tricuspid valve.

Rondot was the first to point out that the hepatojugular reflux was not pathognomonic for tricuspid insufficiency but was found in a wide variety of conditions involving the heart. Because many of his remarks on the differential diagnosis are not available in the English literature, a translation of his conclusions follows (Rondot, 1898):

> 1. The hepatojugular reflux is usually seen in states of low-output cardiac failure (*etats asystolique*) of cardiac or aortic origin, with or without tricuspid insufficiency, when decompensation occurs. It should not be considered pathognomonic of tricuspid valve dysfunction since there is very little correlation with the signs of this latter lesion, particularly by its xiphoid murmur.
>
> Its disappearance usually coincides with the disappearance of the symptoms of cardiac failure, but it can occasionally disappear in the terminal period of cardiac insufficiency or when the latter is complicated by an abundant pericardial effusion. Its absence is usually the rule in valvular heart disease or disease of the aorta or of the pulmonary artery while they are well compensated.
>
> 2. In cardiac dilatations, the hepatojugular reflux is only seen with the weakening of myocardial function:
>
> (a) In acute illnesses of the bronchi and of the lungs and even more particularly in bronchopneumonia, pneumonia, and "splenopneumonia" [right heart failure with secondary tricuspid insufficiency].
>
> (b) In acute illnesses of the digestive tract and of the liver where, however, one does not see it with the same frequency [inferior vena cava obstruction from ascites?].
>
> (c) In nephritis, where its appearance… is rare even during the acute phases of Bright disease specifically, and in the latter is more an indicator of periods of cardiac decompensation that are complications of the "renal heart" [hypertensive cardiomyopathy?].
>
> 3. During pericardial effusions, one does not find any reflux if the liquid is abundant enough to compress the right auricle, but the reflux is usually seen as soon as this compression ceases. Then the reflux disappears again when the auricular myocardium finally regains its normal function.
>
> Thus, one explains the disappearance of the reflux during cardiac failure when pericardial effusion supervenes.
>
> If the state of cardiac failure appears quite evident but is in contrast with heart sounds that are over a large surface, and if the outline of the percussion dullness exceeds inferiorly and laterally beyond the area of the apical impulse and thus reveals a concomitant effusion, the absence of the hepatojugular reflux should put one on guard for the possibility of a vast retrocardiac collection (i.e., pericardial effusion), either free or walled off.
>
> The general conclusion to draw from these facts is that the hepatojugular reflux may be considered a sign of weakening of the right auricular myocardium. Thus, it corroborates signs that are diagnostic of right-sided cardiac insufficiency of either cardiovascular, reflux, or toxic-infectious origin; and the reflux is also able to demonstrate such cardiac failure when the latter's other manifestations are barely noticeable or even remain in a latent state. It thus permits one to institute a medical treatment aimed in a special manner at ameliorating the functions of the myocardium.

A Method (Modified from Ducas et al., 1983)

1. Position the patient with his trunk initially around 45 degrees from the horizontal, and observe the jugular pulsations during quiet breathing. Alter the position as needed to identify the highest angle of elevation at which these pulsations can be seen. This is the baseline venous pressure. (You will be searching for a 3-cm rise in venous pressure. Accordingly, if the jugular vein is too short to demonstrate such a rise, you may have to crank up the head of the bed so that the vein rises 3 cm on the vertical.)
2. Apply your hand to the right upper quadrant or the middle of the abdomen. It is not necessary to press over the liver to produce

the phenomenon. (In fact, if there is tenderness, you should not press in that area because you do not wish the patient to guard, perform a Valsalva maneuver, or interrupt his normal breathing pattern in any way.)

3. Press down, maintaining a pressure of 35 mm Hg. (You can practice over a semi-inflated blood pressure cuff or place the blood pressure cuff over the abdomen to be sure that sufficient pressure is applied.)
4. Instruct the patient to continue to breathe normally through his mouth. Do not attempt to measure the venous pressure for at least 10 seconds to allow both respiratory artifacts and tensing of the abdominal muscles to subside. (Each alters jugular venous pressure.) The best time to take another venous pressure measurement is at 1 minute of pressure. This should be used as the gold standard in ambiguous cases for reasons given in the section "For the Attending."
5. A venous pressure rise of more than 3 cm is abnormal and hepatojugular reflux (or "abdominojugular reflux" as some now prefer) is said to be present (Ducas et al., 1983), assuming of course that pain or performance of a Valsalva maneuver has not produced a false positive.
6. Watch for an abrupt drop in jugular venous pressure as the abdominal pressure is relieved. The sudden fall is generally easier to perceive than the gradual rise (Ewy, 1988).

For the Attending. You will note that performing abdominal compression for a whole minute in a normal subject who does not guard or perform the Valsalva maneuver will usually cause the venous pressure to decrease. The abdominal compression acts as a tourniquet, interfering with venous return to the right heart. It is true that in normals there may sometimes be an initial rise in pressure from the hydraulic effect, but the cumulative effect at 1 minute is a drop in pressure to normal (Hitzig, 1945; Hultgren, 1950).

Some also place the upper normal for sustained increase in venous pressure at 4 cm rather than 3 cm (Cook and Simel, 1996).

Although most authors have advocated 30 to 60 seconds of sustained abdominal pressure, a study correlating the jugular venous pressure rise with hemodynamic measurements concluded that pressure did not change significantly after 10 seconds (Ewy, 1988).

Semeiophysiology

One of the best theories advanced for the mechanism of the abdominojugular reflux, at least in congestive heart failure, is systemic venous hypertension (Burch and Ray, 1954). This makes the venous system an inelastic, tight, noncompliant hydraulic system. In any such hydraulic system, a unit of pressure exerted upon the smaller vessels (e.g., splanchnic veins) is transmitted to the larger vessels (e.g., cervical veins), just as you activate your four automobile brakes by foot pressure on one cylinder.

Ewy suggests that the term "reflux" is inappropriate because the mechanism is not certainly known, hence the designation of "the abdominojugular test" in the section title (Ewy, 1988).

Significance

A positive abdominojugular reflux correlates well with the PCWP. In a study of patients undergoing cardiac catheterization, only one patient with a negative abdominojugular response had a PCWP greater than 15 mm Hg and only three patients with a positive response had a pressure less than 15 mm Hg. It is postulated, however, that right ventricular infarction or other cause of isolated right ventricular failure can cause a positive test in the absence of an elevated wedge pressure (Ewy, 1988). The presence of either a positive abdominojugular reflux test or "jugular venous distention" at rest (Table 19.3) had the best combination of sensitivity and specificity for an elevated PCWP (Butman et al., 1993).

A positive abdominojugular reflux is seen in heart failure, including backward right heart failure, as well as in early or incipient failure. It is also seen in constrictive pericarditis, pericardial tamponade,

TABLE **19.3** *Relation between various findings and elevated PCWP*[a]

Finding	Sensitivity (%)	Specificity (%)	PV + (%)	PV – (%)
Pulmonary rales	24	100	100	35
Third heart sound (S3)	68	73	86	48
Jugular venous distention[b]	57	93	95	47
Positive abdominojugular test or jugular venous distention	81	80	91	63
Pulmonary vascular redistribution on radiograph	65	80	89	48

[a]Elevated PCWP is defined as ≥18 mm Hg.

[b]Jugular venous distention is defined as present if venous pulsations are visible with the patient's head and thorax elevated at 45 degrees from the horizontal or if the venous pressure is estimated to be >7 cm H_2O. This estimate apparently refers to vertical distance above the sternal angle (Ewy, 1983) (but see discussion above on the "cardiologist's constant").

From, Butman SM, Ewy GA, Standen JR, et al. Bedside cardiovascular examination in patients with severe chronic heart failure: Importance of rest or inducible jugular venous distension. *J Am Coll Cardiol.* 1993;22:968–974, with permission.

tricuspid insufficiency, and inferior vena cava obstruction (Ducas et al., 1983; Fowler, 1967), as well as in the conditions noted by Rondot (see the section on "History," above).

There is no abdominojugular reflux in pure left-sided backward heart failure (Hitzig, 1945; Hultgren, 1950). One prospective study showed abdominojugular reflux to have a 66% sensitivity and a 100% specificity for distinguishing tricuspid from mitral insufficiency (Maisel et al., 1984). Thus, Pasteur's original idea was good, albeit restricted.

See Table 19.3 for a comparison of the validity of various signs for an elevated PCWP.

Self-test

In a group of 65 patients, of those with a negative abdominojugular test, one had a PCWP greater than or equal to 18 mm Hg and 43 had a PCWP less than 18 mm Hg. Of those with a positive abdominojugular test, 11 had a PCWP greater than or equal to 18 mm Hg and 10 had a PCWP less than 18 mm Hg. Calculate the sensitivity, specificity, and positive and negative PVs of a positive abdominojugular test for elevated PCWP defined as greater than or equal to 18 mm Hg. Answers are in Appendix 19.3.

For the Cardiology Resident. This sign has long been used to distinguish the hepatomegaly of right heart failure (positive test) from other forms of hepatomegaly (negative test). However, inferior vena cava syndrome, which can produce hepatomegaly and mimic right heart failure in other ways, may be an especially treacherous positive test (i.e., it can lead the unwary to diagnose primary heart failure and to overlook the real problem).

Validity

Some authors have concluded that this test is not useful (Ducas et al., 1983). Curiously enough, even Fowler suggests that "the observation may be confirmed by measuring the pressure in an arm vein with a saline manometer" (Fowler, 1967), although in another context he called the latter method less reliable than inspection of the jugular veins. I find the test very useful when I know that it has been performed correctly by the method described above.

Correlative Signs of Congestive Heart Failure

Venous hypertension and abdominojugular reflux formerly correlated with the presence of an S3 gallop and edema, but nowadays, loop diuretics and vasodilators are given so quickly and frequently that by the time the patient is "stabilized" only the peripheral edema may still be present.

Selective Distention of the Left External Jugular Vein

Selective distention of the left external jugular vein has been reported as a sign of persistent left superior vena cava, which is present in 3% to 4% of patients with congenital heart disease (Colman, 1967; Horwitz et al., 1973). However, increased left jugular vein distention may also be seen in selective compression of the left jugular venous system by aortic dissection or atherosclerotic aortic tortuosity, usually the latter, which additionally may involve the left internal jugular vein owing to left innominate vein compression (Sleight, 1962).

Jugular Venous Pulsations

Normal Venous Pulsations

If there is sufficient undamped distention of the jugular veins, then the venous pulse waves can be analyzed. Undulations called the *A, C*, and *V waves* have been described (Fig. 19-5) but often are not distinctly seen. It is much easier to look for the X and Y descents, two inflickerings of the venous column (each similar to the brief inflickering of the retinal venous diameters at the optic disc in that phenomenon misnamed "retinal venous pulsation" [see Chapter 10]).

The venous pulse can usually be analyzed more readily on the right because the right innominate and jugular veins extend in almost a straight line to the superior vena cava, favoring transmission of hemodynamic changes from the right atrium, whereas the left innominate vein is not in a straight line and may be kinked or compressed by a variety of normal structures, by a dilated aorta, or by an aneurysm (Braunwald et al., 2001).

The A wave (Fig. 19-5) is produced by atrial contraction.

It is possible to diagnose atrial fibrillation on the basis of the disappearance of the A waves. In a 2:1 AV (atrioventricular) block, there will be two A waves in the jugular pulse wave contour for every heartbeat. But in atrial flutter with a 3:1 block, it is almost impossible to pick up three A waves per heartbeat.

The C wave (for cusp) is caused by the bulging of the tricuspid cusps into the right atrium at the beginning of systole, according to Potain. The interval between the A and C waves is, in essence, the PR interval. In Mobitz type I second-degree heart block, the experienced and astute observer will note a gradual prolongation of the interval between the A wave and the C wave in the jugular venous pulse. In fact, this is the way in which Wenckebach discovered his phenomenon, before the invention of the string galvanometer electrocardiograph machine. (He published jugular venous pulsation recordings.) In Mobitz type II second-degree heart block, the interval will not increase, but at the time of the dropped beat, there will be an A wave that is not followed by the customary C wave.

The X descent results from the relaxation of the atrium. The V wave is produced by the volume of blood entering the atrium during ventricular systole (atrial diastole) when the tricuspid valve is closed. The Y descent results from the blood flowing rapidly into the ventricle when the tricuspid valve opens.

Other waveforms are seen in special venous beds with special equipment but not clinically.

A Method

1. Adjust the angle of the bed so that the venous oscillations can be easily seen in the shadow cast by the penlight.
2. With your hand on the point of maximum impulse or on the left carotid (as you are watching the right side of the neck) or with your stethoscope auscultating the patient's heart, time the cardiac cycle. There should be two inflickerings during each cardiac cycle. The brief collapse seen *during* ventricular systole is the X descent. (As you hear S1, simultaneously say "down." The inflickering that occurs during that vocalization is the X descent.) The other collapse, seen during diastole, is the Y descent.
3. Our interest in the X descent is in ascertaining that it is present. (If it is not, that means that ventricular pressure is being

transmitted into the right atrium during ventricular systole because of tricuspid insufficiency [*vide infra*].)

4. Now turn your attention to the Y descent. (The Y descent will be blunted in conditions of impaired ventricular filling such as tricuspid stenosis.)

Teaching Tricks

Photocopy or trace the normal jugular venous pulse shown in the upper left-hand corner of Fig. 19-5 and mark the area that represents systole. Carry this tracing on a card in your wallet, and place it on the pillow next to the patient while examining the jugular pulsations.

Beginners should remember the following caveats:

1. Do not try to learn jugular venous pulsation on any patient who has a pulse rate over 100 beats per minute.
2. Do not try to learn jugular venous pulsations on a patient with a highly chaotic rhythm, such as atrial fibrillation.
3. Note that the jugular venous pulsations are optimally seen only during one phase of respiration in many persons who are breathing deeply. A corollary is that in patients who are breathing deeply and quickly, it may be very hard to learn jugular venous pulsations.
4. The carotid impulse may produce movements that mimic venous pulsations, especially when the carotid pulse is dicrotic. Such false pulsations will continue after you occlude (with a finger) the jugular vein as low in the neck (proximal) as possible. Of course, true jugular venous pulsations will be obliterated by this maneuver and will only return on release of the occlusion. (Also see the section "CV Merger.")

A Note to the Sophomore

The sympathetic outpouring that accompanies cardiogenic shock results in marked venoconstriction so that interpretation of the venous pulsations is not possible. This fact may have discouraged the use of this noninvasive examination in the acute setting. Additionally, many have despaired in their attempts to learn to interpret venous pulsations because they cannot see the textbook findings of distinct A and V waves in many, if not most, normal individuals.

Some may also be discouraged by the fact that the central venous pressure may not correlate well with the pulmonary wedge pressure, especially in patients with acute myocardial infarction. This fact does not detract from the usefulness of jugular venous pulsations in evaluating right ventricular hemodynamics. Even if one cannot recognize subtle changes in A or V waves, one can conclude, with rare exceptions, that no significant abnormality of the jugular venous pulsation is present when there is regular systolic collapse of the vein (Ewy, 1983).

Abnormal Pulsations

CV Merger

In patients with tricuspid insufficiency (see Chapter 17), the regurgitation of blood into the right atrium during systole eliminates the X descent (Fig. 19-5, lower left). The resulting bulge is sometimes called the "CV merger." You can quickly learn to identify this pulse wave contour because there is only one remaining collapse, the Y descent, which is present in diastole, not systole. This sign is not extremely sensitive; only 40% of patients with tricuspid insufficiency will manifest the CV merger (Cha and Gooch, 1983).

Because the X descent occurs during systole, there is an important *false positive*. A hyperdynamic circulation can cause the appearance of giant C waves, obliterating the X descent, in the absence of tricuspid insufficiency. This apparent CV merger is due simply to the hyperdynamic stroke of the carotid arteries transmitted through the cervical tissues, making the veins appear to bulge out during systole.

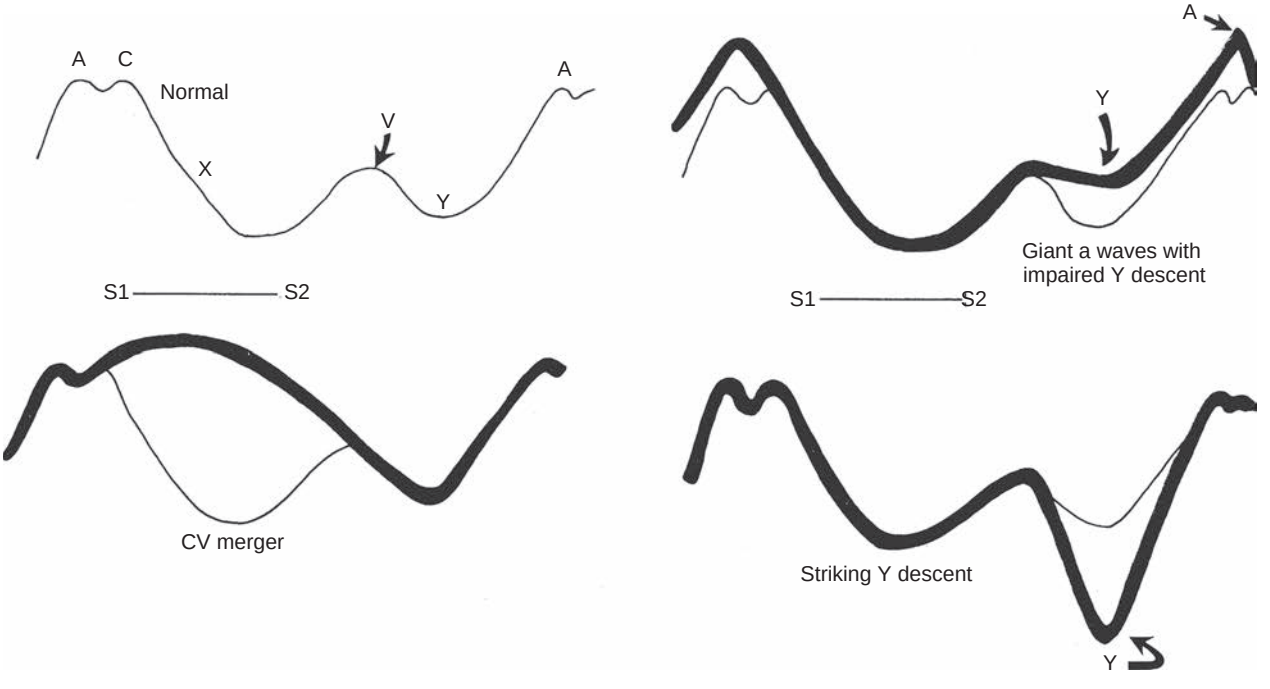

Figure 19-5 Jugular venous pulsations. Idealized normal **(top left)**, and abnormal tracings superimposed on the normal. See text.

To distinguish this artifact from a true positive, try the following: (a) If you are inspecting the external jugular, try teaching trick 4. Simply compress the external jugular vein between the site of inspection (the apparent CV merger pulsations) and the heart. If the giant C waves continue, they are presumably transmitted carotid pulsations. (b) Can you obliterate the giant C waves by compressing the ipsilateral carotid artery? If so, they are false positives, not true venous waves. (c) Is the venous pressure elevated? Dr Mike Fisher of Maryland believes that CV merger should not be accepted in the absence of an increased venous pressure. (d) Do the pulsations change with the patient's position? Venous pulsations may be present or absent depending on the patient's position, whereas arterial pulsations are minimally changed. (e) Are the pulsations subject to respiratory variation? Venous pulsations are; arterial pulsations are not. (f) Does abdominal compression change the height or motion of the pulses? If so, they are venous (Ewy, 1987).

Laënnec was not the first person to observe CV merger. But while others confused it with the carotid pulse from a hyperdynamic left ventricle, Laënnec knew how to distinguish the two conditions, and he stated that he had never seen CV merger without right ventricular "hypertrophy" (failure).

CV merger has also been reported in atrial fibrillation (Marriott, 1989).

Giant A Waves with Blunted Y Descent and a Note on Cannon A Waves

Tricuspid stenosis results in a *blunted Y descent* and giant A waves (Fig. 19-5, upper right). The giant A wave is caused by the atrium contracting against a stenotic tricuspid valve, pushing blood back up into the cervical veins. Similarly, the blunted Y descent in early diastole reflects impairment of blood flow into the right ventricle. The same type of pulse tracing may be seen with increased right ventricular end-diastolic pressure as in pulmonic stenosis (infundibular or valvular), pulmonary vascular obstruction (primary pulmonary hypertension or pulmonary embolism), chronic pulmonary disease, large right atrial clots or tumors, and cardiomyopathies (congestive, hypertrophic, and restrictive) (Ewy, 1987). This type of pulse wave tracing may appear to have only one venous collapse (the X descent), which occurs in systole.

I became convinced of the importance of the Y descent when I saw Dr Frank Kroetz of Tennessee diagnose stenosis of the tricuspid valve on the basis of a blunted Y descent alone, in a patient who also had mitral stenosis, at a time when the textbooks said this was an impossible pair of diagnoses to make. Dr Kroetz stated that his diagnosis was confirmed by the presence of two opening snaps. Cardiac catheterization proved him correct.

Giant A waves should not be confused with *cannon A waves*. Giant A waves occur on every beat (if the patient is in sinus rhythm), but cannon A waves, a specific sign of AV dissociation, occur *irregularly on a minority of beats*. A cannon A wave is produced during AV dissociation if the atria happen to contract at a time when the (dissociated) ventricular contraction has just shut the tricuspid valve. The atrial systolic stroke volume, being denied egress to the right ventricle, has nowhere to go but back into the venous system, producing the cannon A wave. But because it is a rare coincidence for the dissociated atrial and ventricular contractions to occur in the requisite sequence, the cannon A waves occur irregularly (randomly) and on a minority of beats. In a sense, they result from the same mechanism as the giant A waves; both are the result of impaired right ventricular acceptance of the atrial systolic stroke volume, one relatively fixed and one intermittent.

The rate of rise of a cannon A wave is very brisk. Thus, it has been described as "flippy" in quality, while the regurgitant CV wave appears to "well up" during systole (Ewy, 1983).

For the Very Advanced Student. Cannon A waves can also occur during premature ventricular contractions with retrograde conduction. Or, if a long PR interval is interrupted by a premature atrial contraction so that the tricuspid valve leaflets have floated back almost to the closed position before the atrial contraction occurs, a single cannon A wave may result.

Some junctional (nodal) ectopic rhythms can produce cannon A waves. This is the only situation in which the cannon A wave can be seen on every beat or at least on every beat that involves retrograde conduction of the ectopic impulse to the atria.

With AV nodal reentrant tachycardias, the cannon A wave and the carotid pulsation arrive in the neck simultaneously. The history of feeling rapid and regular pounding in the neck during the palpitations discriminated AV nodal reentrant tachycardia from other tachycardias with a sensitivity of 92%, a specificity of 100%, a positive likelihood ratio (LR) of 350, and a negative LR of 0.1 (McGee, 2001).

Head Bobbing in Right Ventricular Failure

Gentle lateral head movements following the V wave and the A wave of the jugular venous pulse have been described in patients with severe right ventricular failure. These movements, called *head bobbing*, are best seen from the foot of the bed, with the patient supine and relaxed. In a series of eight patients, all had prominent A and V waves (with the A wave exceeding 20 mm Hg) and a rapid Y descent, a left parasternal precordial impulse, and atrial and ventricular gallops. Six had a murmur of tricuspid regurgitation. Similar head motions have not been demonstrated in patients with tricuspid stenosis or right atrial myxoma, although they might be expected. In the absence of tricuspid stenosis, the giant A wave is thought to provide evidence of impaired right ventricular performance and altered right ventricular compliance (Rios et al., 1973).

Rapid Y Descent

A rapid Y descent (Fig. 19-5, lower right) occurs in about one third of patients with constrictive pericarditis. If the patient is not properly positioned, the jugular pulse may appear to have but one inflickering per cardiac cycle, occurring in diastole, not systole. That appearance could lead you to believe that you are really dealing with the CV merger of tricuspid insufficiency. To bring out the normal X descent of constrictive pericarditis, raise the head of the bed a little, and the X descent will appear. If the patient really has CV merger from severe tricuspid insufficiency, the X descent cannot be demonstrated no matter how far you raise the bed. The prominent Y descent of the jugular veins was formerly known as the Friedrich sign (Friedrich, 1864, 1865).

The rapid Y descent is a good sign of constrictive pericarditis and restrictive right ventricular disease. It may also be seen in right ventricular infarction, but this is controversial (Table 19.2; footnote *b*). Its absence is of no use. But its presence excludes the diagnosis of

pericardial tamponade. The semeiophysiology is that with constriction, the impairment in ventricular filling is minimal in early diastole, but the pressure rises abruptly when cardiac volume reaches the anatomic limit set by the noncompliant pericardium. The prominent *Y* descent followed by an elevated plateau of ventricular pressure is called the "dip and plateau" or "square root" sign. In contrast, with tamponade ventricular filling is impaired throughout diastole, and the *Y* descent is absent (Manning, 2007).

A logical flow chart for venous pulsations is given in Fig. 19-6.

Atrial Septal Defect Pattern

A characteristic jugular venous pulse has been noted in 41% of patients with atrial septal defect (Tavel et al., 1968). It is characterized by high-peaked V waves, which often exceed the A waves in height. This pattern indicates the presence of a large left-to-right shunt, and it is lost when pulmonary hypertension supervenes. It is rarely seen in persons without atrial septal defects.

A Historic and Epistemologic Perspective: A Case of Vasovagal Syncope

To illustrate the current desuetude of clinical examination, note that in the classic report on vasovagal reflex causing complete heart block (Weiss and Ferris, 1934) the diagnosis was made during a spontaneous attack when the patient was not connected to an electrocardiograph. The authors observed that "the venous pulsations over the neck were more rapid than the apical rate."They were sufficiently confident of this observation that they subsequently passed a small rubber balloon into the patient's esophageal diverticulum and inflated it to induce complete heart block. By this means, they reproduced the patient's symptoms, which had usually been precipitated by swallowing food, especially sticky food such as peanut butter and crackers.

Auscultation

Venous Hums

Cervical Venous Hum

A more or less continuous murmur emanating from the cervical (jugular) veins is called a *cervical venous hum*. Its only significance is that it may be confused with pathologic murmurs, especially when the hum is louder either in systole or diastole.

One can stumble upon the cervical venous hum in 2.3% to 27% of adult outpatients (Braun et al., 1966; Jones, 1962) and in 31% to 66% of normal children (Graf et al., 1947), regardless of any underlying disease, especially if the patient is examined in the sitting or erect position during quiet breathing. The hum can be heard anywhere in the lower neck and is abolished during (a) the Valsalva maneuver, (b) recumbency, or (c) compression of the ipsilateral internal jugular vein distal to the point at which the venous hum is heard. The last can be achieved by pressing just lateral to the thyroid cartilage (Jones, 1962). Venous hums tend to be louder when the head is turned away from the side of auscultation (Sauvé et al., 1993).

Patients on renal dialysis have a very high incidence of cervical venous hums: 56% to 88% prevalence during hemodialysis and 34% between dialysis treatments (Wheeler, 1982). Although attributed to the increased blood flow through their access fistulae, compression of the artery leading to the fistula does not decrease the hum (as opposed to the flow murmur discussed in Chapter 18).

Venous hums are also discussed in Chapters 17 and 20.

Other Findings

A midsystolic jugular or clavicular venous pistol shot may be heard in tricuspid insufficiency. If the patient has varicose veins in

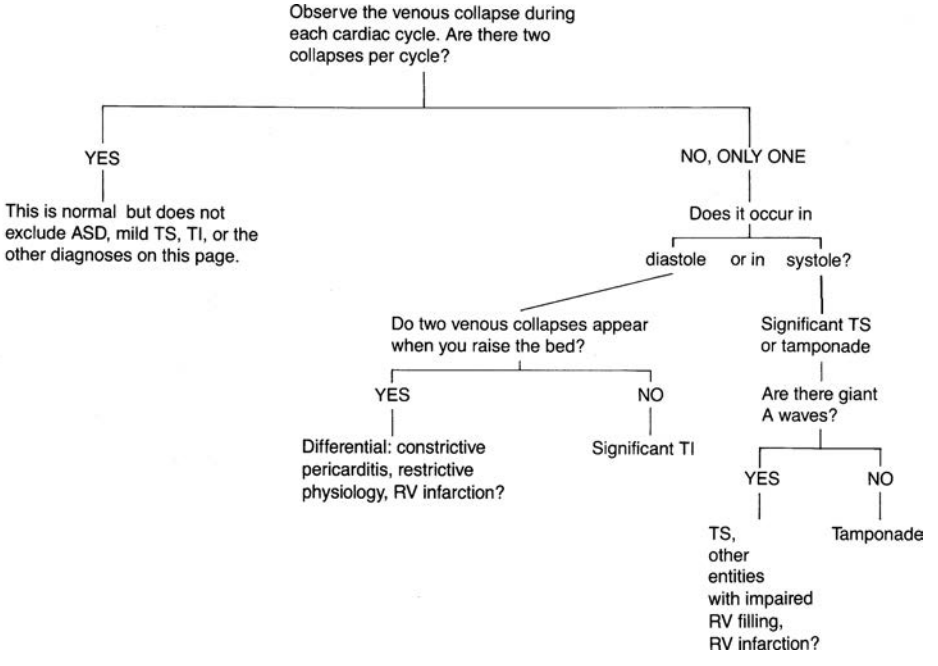
Observe the venous collapse during each cardiac cycle. Are there two collapses per cycle?
YES
This is normal but does not exclude ASD, mild TS, TI, or the other diagnoses on this page.
NO, ONLY ONE
Does it occur in
diastole or in systole?
Do two venous collapses appear when you raise the bed?
YES
Differential: constrictive pericarditis, restrictive physiology, RV infarction?
NO
Significant TI
Significant TS or tamponade
Are there giant A waves?
YES
TS, other entities with impaired RV filling, RV infarction?
NO
Tamponade

FIGURE 19-6 Logical flow chart for venous pulsations. TI, tricuspid insufficiency; TS, tricuspid stenosis; ASD, atrial septal defect; RV, right ventricle.

the leg, it may be possible to hear the murmur of tricuspid insufficiency disease there (see Chapter 17).

A jugular or clavicular presystolic click has been heard in tricuspid stenosis and other conditions of high central venous pressure (Fisher, 1984).

Venous Syndromes

Superior Vena Cava Syndrome

Obstruction of the superior vena cava by thrombosis or by external compression (e.g., from tumor) is called the *superior vena cava syndrome*. The first three venous signs to be discussed can all be demonstrated at the bedside once one has mastered the determination of venous pressure and the Kussmaul sign. However, the beginner should use manometry to learn and to demonstrate these signs in a more replicative fashion. Note that manometry can be performed in any accessible lower-extremity vein, most conveniently the long saphenous vein anterior to the medial malleolus.

The first sign, an elevation of venous pressure in the arms (or neck) in the presence of normal lower-extremity venous pressures, is pathognomonic for superior vena cava syndrome. The second sign, also pathognomonic, is a further elevation of the upper-extremity venous pressure following the placement of a tourniquet around the patient's *upper* thorax. Simply have the patient lie on the tourniquet before you measure the baseline venous pressure, and when you are ready to do this test, pull the two ends of the tourniquet over the anterior chest where they may be tied snugly enough to prevent caudad flow through the chest wall venous collaterals. (This test works even when these venous collaterals are not visible.) Third, there is the Kussmaul sign, which is less specific in the diagnostic sense.

It should be clear that the cost of the radiologic procedures needed to replace the above diagnostic maneuvers (such as CT scan, magnetic resonance imaging [MRI], and venography) is easily an order of magnitude beyond the money "saved" by third-party payers reluctant to reimburse expenses for venous pressure determinations. Obviously, these tests could also be used to monitor the results of therapy given for superior vena cava syndrome.

Additional signs occurring in *chronic* superior vena cava syndrome include visible anastomotic veins and the reversal in the usual direction of drainage of the supraumbilical abdominal veins (Chapter 20), which can be determined by stripping the vein in the manner shown in Fig. 19-2.

In an earlier era, one could use red-tinted glasses, worn by fluoroscopists to speed accommodation to the darkness of the fluoroscopy suite, to enhance examination of such superficial veins (Fear and Muggia, 1962; Sprunt and Wolff, 1962). Alas, image intensifiers have made these goggles as obsolete as the bromsulphthalein retention test.

Portal hypertension of otherwise unexplained etiology in the presence of the superior vena cava syndrome tells you that the obstruction is below the part of the superior vena cava that receives the azygos vein. A 29-year-old patient of Dr Bob Meyer of Indiana was admitted with a superior vena cava syndrome and esophageal varices. The etiology of the syndrome was demonstrated to be fibrosing mediastinitis. A venogram revealed bilateral cutoff at the level of the axillary veins, but the presence of portal hypertension led the antediluvian clinicians to insist upon the presence of an additional obstruction below the entrance of the azygos vein into the superior vena cava. This was later documented by an MRI scan (done in an attempt to delineate the anatomic relations sufficiently to permit a surgical procedure). In this situation, the azygos vein shares the venous hypertension and acts as a decompressing collateral, reversing the flow through the esophageal veins (which become varices) and thence to the coronary veins and so into the portal circulation. This is the same route (but with a reversal of flow) as seen in the more usual primary portal hypertension. Conversely, if there is no portal hypertension, one can only say that the patient has not had the syndrome long enough and/or that the obstruction is above the entrance of the azygos vein into the superior vena cava.

Inferior Vena Cava Syndrome

In the inferior vena cava syndrome, the venous pressure (measured by manometer) should be elevated in the lower extremities but not in the upper. This lower-extremity pressure should rise further with a tourniquet secured snugly around the waist of the patient, thus cutting off the decompressing cephalad flow in the collaterals. Dr Laura Miketo of Ohio has noted an additional sign: The pressure in the upper manometer actually drops during the tying of the tourniquet and then rises when the tourniquet is released as the pressure in the lower-extremity manometer is dropping.

Deep Vein Thrombosis

Upper-extremity Deep Vein Thrombosis

Thrombosis of the axillary and/or subclavian vein is an excellent example of an entity that can be diagnosed clinically by the concatenation of individually nonspecific findings. Spontaneous thrombosis tends to affect the left side and posttraumatic thrombosis the right side. The patient is usually a young active man. Pain or swelling of the affected side is the first symptom. There is always swelling (usually nonpitting) that can be quantitated by circumferential measurement. Dilated collateral veins are always seen in white patients and often in black patients. Arm discoloration is also reported in 70% of white patients. A palpable vein (often the axillary) is present in only about one third of the patients. Venous pressures are elevated on the affected side only (Adams and DeWeese, 1971; Prescott and Tikoff, 1979).

Lower-extremity Deep Vein Thrombosis

In patients complaining of pain and swelling in the calf, the possibility of deep vein thrombosis is always a concern and is difficult to rule out clinically. Although the signs to be given are not individually perfect (Table 19.4), they are suggestive of the diagnosis if they occur together, provided that one has ruled out mimics such as the pseudothrombophlebitis syndrome (see Chapter 24).

There is also a syndrome seen in patients with mild venous incompetence (often manifested by an aching in the legs with prolonged standing, which is relieved by elevating the legs) that closely resembles deep venous thrombosis in every respect except the severity of discomfort. This may result from acute decompensation of the deep venous system, in the absence of true venous obstruction by thrombus, and responds to 24 to 48 hours of leg elevation

TABLE **19.4** *Clinical signs in thrombophlebitis*

Sign	Sensitivity (%)	False-positive rate[a]
Rubor (redness)	16	13
Venous dilatation	25	11
Calor (heat)	29–50	0–23
Tenderness	41–60	11–61
Tumor (swelling)	81–83	6–55
Homan sign[b]	8–10[c]	11–12

[a]Prevalence of the sign in suspects without the disease.
[b]Homan withdrew his own eponym (which he had never claimed), preferring "dorsiflexion sign" (McLachlin et al., 1962).
[c]DeGowin (1965) claims 35%.
From McLachlin J, Richards T, Paterson JC. An evaluation of clinical signs in the diagnosis of venous thrombosis. *Arch Surg.* 1962;85:738–744, with permission, and Vaccaro P, Van Aman M, Miller S, et al. Shortcomings of physical examination and impedance plethysmography in the diagnosis of lower extremity deep venous thrombosis. *Angiology.* 1987;38:232–235, with permission.

without the need for anticoagulation. Noninvasive vascular studies are needed to make the distinction (W.D. Jordan, *personal communication*, 1998).

Predisposing Factors

The Virchow triad, first described in 1860, is vein wall damage, stasis, and hypercoagulability. Patients undergoing major orthopedic procedures are at highest risk (48% to 71%). As diagnosed by fibrinogen leg scanning, deep venous thrombosis occurs in 24% of patients with myocardial infarction and in the weak limb of 42% of patients with stroke. In such populations, the condition is underdiagnosed, whereas 60% to 80% of patients from the general population referred for diagnostic testing do not have the diagnosis confirmed (Kahn, 1998).

Up to 10% of long-haul air travelers may develop asymptomatic deep venous thrombosis (Scurr et al., 2001); 1%, most with preexisting risk factors, may develop symptoms of thromboembolism (Hughes et al., 2003). Immobilization and dehydration are two important factors. Hypoxia may add to the risk as the partial pressure of oxygen in commercial air cabins is the equivalent of breathing 15% oxygen at sea level (James, 1998). Some researchers have found that coagulation is activated by acute hypobaric hypoxia at levels similar to those in aircraft cabins (Bendz et al., 2000), although this finding was not confirmed by others under somewhat different conditions (Bendz and Sandset, 2003; Crosby et al., 2003).

Inspection

Check the popliteal space, the saphenous vein in the thigh, and the superficial veins for visible inflammation.

The Pratt sign is the presence of three dilated veins, called *sentinel veins*, over the tibia. The dilation persists when the legs are elevated to 45 degrees. In fact, one, two, or four such veins would have the same significance but do not yet have eponyms. You may want to stake a claim. (A patient admitted for the evaluation of a lung mass had dilation of three veins over his left shin when supine. The veins on the right side were not dilated, and there was no evidence of thrombophlebitis. However, the veins collapsed when the legs were elevated, so this was not the Pratt sign. The patient had pelvic vein compression due to prostatic carcinoma.)

Palpation

Palpate for cords in the greater saphenous vein and its branches. In a unilateral thrombophlebitis of the calf or the thigh, an increase in skin temperature may be found. When seeking this sign, ignore the knees. (Warmth over the knee may result from arthritis, Paget disease synovitis, or the collateralization of arterial disease [see Chapter 18].) Presence of a cord is highly specific (98%) but the sensitivity is low (10%) (Kahn, 1998).

Also check for pitting edema. Before edema is apparent to inspection, it can thicken the skin enough to make it feel "stiff" (compared with the other side) when one pinches it (the Rose test).

Percussion

The Lisker sign is tenderness to percussion of the medial anterior tibial surface. The Lisker sign is said to be present in 65% of patients with thrombophlebitis (DeGowin, 1965) but, unlike the Homan sign, is absent in lumbosacral disease.

Special Maneuvers

1. *Localizing tenderness.* Grasp the soleus muscle and pull it and the gastrocnemius muscle posteriorly and superiorly, away from the tibia. Now squeeze the muscles gently from the side. (Start at the bottom and inch up.)

   If pain is produced by this maneuver (called the *Bancroft sign* or the *Moses sign*), the patient either has muscle pain or thrombosis of the veins of the soleus but not necessarily thrombophlebitis of the (deep) posterior tibial vein.

   Next, press the gastrocnemius forward against the tibia. If this produces pain, greater than before, one has found thrombophlebitis of the posterior tibial vein.

   Calf pain and tenderness are the findings of highest sensitivity (90% and 84%, respectively) (Kahn, 1998).
2. *Quantitating tenderness.* In the Lowenberg sign, the two calves are wrapped with cuffs to see whether both can tolerate a pressure of 180 mm Hg and whether both are equally sensitive. Because the sign involves two variables and vague criteria, I prefer the modification taught to me by Dr Jim Scheuer of New York: Wrap a blood pressure cuff around the extremity and pump it up, noting the pressure at which pain occurs. The sign is positive when pain occurs on the affected side at one half the pressure required on the normal side. This sign has a high specificity (85%) (Kahn, 1998).

   In yet another modification, Ramirez simply inflates the cuff to 4 mm Hg above the venous pressure and waits for the pain to appear. In thrombophlebitis, the pain is said to increase over 5 minutes of occlusion and to improve with the eventual release of the pressure. Unfortunately, the same thing may happen in a normal patient, so one should modify this test to include a comparison with the normal side.
3. *The Homan sign.* If passive dorsiflexion of the foot produces calf pain, the patient is said to have the Homan sign. False positives

are seen in women who wear high heels ("*Bailey*", Clain, 1973), as well as with herniated intervertebral discs and other forms of lumbosacral disease (DeGowin, 1965).

4. *The Louvel sign*. This is venous pain induced by coughing; it is prevented by pressing over the proximal end of the vein with the finger to block the venous distention.
5. *Quantitation of swelling*. Quantitation of the swelling of the affected side is useful if the thrombophlebitis is unilateral. Both legs should be measured a given distance up and down from the patella or the tibial plateau—for instance, 10 cm down from the tibial plateau on both sides for the calf and 20 cm above the superior border of the patella for the thigh. (Obviously, an elastic tourniquet is not a suitable measuring device, although a graduate of a U.S. medical school was once observed to be using it as such.) On the basis of 95% confidence limits,[3] the circumferences of normal thighs are different by less than 1.5 cm and abnormal thighs (as judged by impedance plethysmography) are different by more than 1.9 cm (Hull et al., 1985). (Unfortunately, there are still differences in shape, total body size, and distance above the tibial plateau that have not been addressed in the literature.)

   Similarly, the calves are normally within 1.68 cm of each other. Abnormal calves (as judged by impedance plethysmography) tend to be different in circumference by at least 2.5 cm (Hull et al., 1985).

   False Positive. One resident physician noted that she had a chronic calf asymmetry of more than 2 cm but no history of venous disease or other disease of the lower extremity. She believed the asymmetry to be attributable to the fact that one of her legs was shorter than the other. When she leaned over to touch her toes, it was apparent that the thinner calf was, as expected, that of the longer leg. (The length of the leg can be measured using the method described in Chapter 25. In this case, the pelvis could be seen to be tilted ever so slightly, and the sacroiliac joint of the longer leg was a bit higher than the other.)
   Also see pseudothrombophlebitis (see Chapter 24).
6. *Limits of thrombosis and location of swelling*. Just as the site of arterial disease is shown by the location of the muscle pain, the location of a venous thrombosis can be determined from the pattern of the swelling. The proximal extent of the swelling will be beneath the next major patent tributary in the deep venous system. Hence, if the superficial femoral vein is occluded but the deep femoral vein is patent, the swelling will not extend above the knee. If the external iliac vein is occluded but the internal iliac is patent, the swelling will stop at the inguinal ligament (W.D. Jordan, *personal communication*, 1998).

[3] A statistical note: The distributions have been recalculated from the original paper and expressed in 95% confidence limits because that is the way the clinician thinks with an individual patient before him. The standard deviation is useful in animal experiments, but the standard deviation increases with an increasing sample size. To present a clinician with a standard deviation assumes that (a) his population size is the same as that in the published paper and that (b) with increasing experience his population size will not increase. The latter is obviously unrealistic except for very rare conditions. The standard error of the mean improves the situation somewhat for the experimentalist who wishes to know whether the difference between two groups is greater than could be expected by chance. What the clinician wishes to know is how his individual patient compares with a group of normal patients. For this, the 95% confidence limits give him the answer. As a rough rule, doubling the quotient of the standard deviation (divided by) and the square root of the sample size gives the 95% confidence limit of that mean (e.g., mean = 100, SD = 24, n = 16, 95% confidence limits = 88 to 112).

Prediction Model

The diagnosticity of various signs, whether taken singly or in combination, is rather poor. A logistic regression model found that nine clinical features independently predict deep venous thrombosis. Assigning an integer score to each of these enables the calculation of a sum that predicts the probability of the diagnosis. One point is assigned to each of the following: active cancer, paralysis or recent plaster cast, recent immobilization or major surgery, tenderness along deep veins, swelling of entire leg, calf circumferences of two legs differing by more than 3 cm, pitting edema, or collateral superficial veins. Two points are subtracted if an alternative diagnosis is likely. A sum of 3 or more represents a high probability of deep venous thrombosis; 1 to 2, a moderate probability; and less than 1, a low probability (Kahn, 1998).

Trousseau Syndrome

> *I am lost; the phlebitis that has just appeared tonight leaves me no doubt about the nature of my illness*
>
> (A. Trousseau, quoted in Stolinsky, 1983).

Trousseau syndrome is clinically apparent thrombophlebitis (either superficial or deep) in association with malignancy. It is often migratory, and it may occur in somewhat unusual sites (e.g., arm veins). Although originally described in association with gastric carcinoma (the diagnosis Trousseau made in himself), that disease has become rarer since the original description. Pancreatic carcinoma, for which Trousseau sign has a sensitivity of less than 14% (Pinzon et al., 1986), is now much more common. Other associations are with carcinoma of the lungs, breast, prostate, and even head and neck squamous cell carcinomas. The risk is higher in cancer patients undergoing chemotherapy. In one controlled trial of two adjuvant regimens, all thrombotic events occurred during the months the patients were receiving chemotherapy (Kahn, 1998).

Varicose Veins

Varicose veins are tortuous, dilated, and lengthened veins. They are diagnosed by inspection, with the patient standing.

When occurring in combination with port wine staining of the skin, varicose veins are strongly suggestive of an arteriovenous fistula. Varicose veins may pulsate in tricuspid insufficiency even when you cannot hear the murmur over the veins (Brickner et al., 1962).

Greater Saphenous Vein Tests

Trendelenburg–Brodie Test

The Trendelenburg–Brodie test was first described by Brodie (1846) but is usually attributed to Trendelenburg, who was 2 years old in 1846 and did not publish a paper on the test until 1890.

A Method

1. Elevate the limb to be examined, thus draining it passively.
2. Compress the greater saphenous vein at midthigh with your fingers, a tourniquet, or a blood pressure cuff inflated above the venous pressure but below the arterial pressure.
3. Have the patient stand for a minute. If the arterial supply is normal, the greater saphenous vein will fill *slowly* over half a minute. Rapid filling indicates backfilling from incompetent communicating veins.
4. Release the tourniquet. Further backfilling at this point requires that the greater saphenous vein valves be incompetent (as they will be in a distended vein).

False positives are produced by failing to initially drain the vein (step 1) or by otherwise distending it (Trendelenburg, 1890). Arterial insufficiency will produce a false negative.

Trendelenburg described two other tests:

1. The first test makes use of the fact that in the supine patient, the blood column in the greater saphenous vein forms a sort of manometer attached to the abdominal cavity. If the leg is elevated slightly above the level of the heart, the fluid level in an incompetent saphenous vein rises with coughing, straining, or even with flicking a finger against the abdominal wall.
2. To check for the presence of communicating veins to the deep veins (before ligating the greater saphenous vein), Trendelenburg recommended compressing the greater saphenous vein with the patient horizontal and the varices filled, and then raising the leg high. If the greater saphenous vein is the only efferent channel, the varices remain filled, but if there are communicating channels, the varices empty, albeit slowly (Trendelenburg, 1890).

Perthes Test[4]

A Method

1. While the patient is standing, apply a tourniquet (or a blood pressure cuff inflated above the venous pressure and below the arterial) at midthigh.
2. Have the patient walk around the room for 5 minutes with the compression in place and note the effect on the vein.

Interpretation. Normally, the muscle compression will empty the greater saphenous vein through normal communicating veins, which will drain through normal deep veins. Thus, the normal greater saphenous vein will actually be smaller after the walk.

If the greater saphenous and communicating veins are both incompetent, there will be no emptying and no change in the size of the visible greater saphenous.

If the deep vein is obstructed and the communicating veins are incompetent, there will be a further increase in venous distention, often accompanied by pain.

[4] G.C. Perthes is today remembered only as one of the triumvirate who described in three different papers, in as many languages, Legg–Calvé–Perthes disease in 1910. But he was actually a pioneer in the radiation therapy of carcinoma (Perthes, 1903).

The Percussion Test

A Method

1. Place the sensitive fingers of one hand on the greater saphenous vein below the knee.
2. Place the other hand at least a foot away, above the knee, and with the tips of the fingers rap the greater saphenous vein sharply (about 60 mm Hg per 100 millisecond) so as to send a fluid wave through it.

Interpretation. If the greater saphenous vein valves are incompetent (as surely they will be if that vein has become so distended that it can be seen and palpated over the distance of a foot), then it may be possible to feel the venous impulse traveling backward down the leg.

False positives may result from thrombosis of the vein or from a blow so hard that it causes shaking of the leg muscles, which is misinterpreted. False negatives may result from too light a blow or insufficiently sensitive palpating fingers.

Chronic Venous Stasis

Chronic edema and venous incompetence results in stasis dermatitis, beginning as mild erythema and scaling over the medial ankle or a varicose vein. Pigmentation develops as a consequence of extravasation of blood and hemosiderin deposition. Stasis dermatitis may become acutely inflamed, with exudation and crusting. Dermal fibrosis often occurs with brawny edema, complicated by ulceration. (Also see Chapters 7 and 24.)

Appendix 19.1

The Circulation Time

A Method

1. Continuing from the manometric determination of venous pressure (see earlier in this chapter), switch the stopcock so that the manometer port is now disconnected from the vein and the injection port is now connected to your injector syringe, which has been filled with an indicator of your choice (Table 19.5).
2. Instruct the patient to begin searching for the subjective sensation, for those maneuvers utilizing such an end point. Review the agreed-upon signal for the detection of the subjective sensation, where relevant.
3. Start your stopwatch and rapidly inject the indicator substance.
4. Stop the stopwatch at the end point (Table 19.5).

Interpretation

Prolonged circulation times are found in low-output congestive heart failure. False positives occur in myxedema and polycythemia. False negatives (i.e., shortened circulation times, or in the case of congestive heart failure, shorter than expected circulation times) occur in right-to-left shunts and high-output states with or without supervening congestive heart failure. The latter include hyperthyroidism, anemia, beriberi, arteriovenous fistula (including severe erythrodermatitis, pregnancy, and Paget disease), and fever. Some have argued for abandoning the circulation time because

TABLE **19.5** *Indicators used in determining circulation time*[a]

Indicator	End point	Normal time (seconds)	Advantages and disadvantages
5 cc of 20% Decholin (sodium dehydrocholate)	Bitter taste	10–16	Excellent end point but requires conscious, articulate patient; Decholin difficult to find; rare anaphylaxis
2 cc of 20% solution or 3 cc of 15% solution or 4 cc of a 10% solution of fluorescein (the last is used for fluorescein angiography in ophthalmology dept.)	Greenish fluorescence of the lips, tongue; histamine-wheal anywhere on body	10–16	Requires Wood's light; does not require patient cooperation; correlation with Decholin circulation time (the gold standard) excellent (Knott and Barlow, 1964)
3–5 cc of 20% calcium gluconate	Hot sensation in the throat	10–16	End point difficult for some patients to describe, offsetting ubiquity of calcium gluconate
10 cc of 10% magnesium sulfate	Same as calcium gluconate	7–17	Same as calcium gluconate (the two can be mixed)
0.8 mg/kg body weight riboflavin	Fluorescence; see fluorescein above	10–16	Injectable riboflavin may be difficult to find on the spur of the moment
2.5 cc of a solution prepared by dissolving 2.5 g of saccharin in 2 cc of warm, not boiling, water; sterilize by passing through a millipore filter	Sweet taste	9–16	—
0.5 cc of 1% alpha lobeline	Cough, followed by hyperventilation	11–12	—
Five drops of ether in ten drops of normal saline (paraldehyde is safer)	Characteristic odor	4–8	—

[a]The arm-to-tongue (or other arterial target) circulation time is the total circulation time. The arm-to-lung circulation time (as determined with ether) is essentially the "right-sided" circulation time; if it is subtracted from the total circulation time, one obtains the "left-sided" circulation time. The left-sided circulation may also be directly measured because inhalation of 50% carbon dioxide produces hyperpnea and tachypnea when the bolus reaches the carotid sinus (normal = 5–10 seconds). In cases of pure "backward" left- or right-sided failure, only the circulation time for the afflicted segment may be prolonged.

its correlation with cardiac output (index) was once "only" 0.64, $p < 0.05$ (Selzer et al., 1968), when both variables were treated as continuous. Yet, if one wished to use the test only as a means of diagnosing the presence or absence of congestive heart failure on the basis of a dichotomous classification of an abnormal or a normal circulation time, it would appear in an even more favorable light.

Appendix 19.2

Answer to Self-test on the Kussmaul Sign

The epigram cannot be the first description of Kussmaul sign in pericardial tamponade for the following reasons:

1. Julian was stabbed in the liver, not in the pericardium.
2. The translation is wrong. Actually, the *inspirations* are being choked off by the veins.
3. Finally, you do not get the Kussmaul sign in pericardial tamponade but in constrictive pericarditis and right ventricular infarction. (Table 19.2.)

Appendix 19.3

Diagnosticity of the Abdominojugular Reflex

In this study, there were 11 true positives, 10 false positives, 1 false negative, and 43 true negatives. Thus, the sensitivity = 92%, the specificity = 81%, the PV of a positive test = 52%, and the PV of a negative test = 98%.

Of course, these values would all change if the cutoff point for an elevated PCWP were changed. In this study, if an elevated PCWP of 15 cm or greater is defined as abnormal, the true positive = 18, the false positive = 3, the true negative = 37, and the false negative = 7. Then, the sensitivity would be reduced to 72%, with the specificity = 92%, the PV of a positive test = 86%, and the PV of a negative test = 84%.

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CHAPTER 20

The Abdomen

Every month for three successive days they purge themselves, for their health's sake, with emetics and clysters, in the belief that all disease comes from the food a man eats.

—Herodotus, *The Histories*, Book 2

Points to Remember:

- Inspect the abdominal wall for asymmetry, distention, displacement of the umbilicus, respiratory motions, ecchymoses, and venous patterns.
- Listen, especially for bowel sounds, before palpating. Also check for hums, bruits, and rubs.
- Palpate the abdomen in an orderly sequence, reserving any painful areas for last.
- Consider the possibility of pregnancy in all women of child-bearing age.
- Palpate for tenderness, masses, abnormal pulsations, and enlargement of organs or the aorta.

Inspection

Contour

One should always take a moment to stand at the foot of the bed and look at the nude abdomen. This has been traditionally taught as a useful way to observe visible peristaltic waves in cases of intestinal obstruction. Dr A.I. Mendeloff of Maryland points out that it is even better for noticing asymmetry due to hepatomegaly and splenomegaly. These organs are sometimes more obvious on inspection than on palpation. (Also see "Ascites" discussed later in this chapter.)

Cope states that the ladder pattern of abdominal distention visualized on the anterior abdominal wall indicates obstruction of the lower ileum (Silen, 1979). He also states that moderate distention of the large bowel can be seen on the anterior abdominal surface as an inverted "U" extending from the right lower quadrant to the right upper quadrant, across to the splenic flexure, and down to the left lower quadrant. (In both cases, the drawings that are presented really resemble the patterns of dilated bowel seen on flat plates of the abdomen in those conditions.) In recent experience, these patterns are uncommon and incomplete. I suspect that Cope's patients were much thinner.

Pseudocyst of the pancreas may produce a localized bulge.

When inspected from the side, patients with acute pancreatitis show a peculiar Cupid's bow profile (Fig. 20-1A). The dimple in the Cupid's bow is approximately at the umbilicus. The absence of this sign in a patient with a known elevation in amylase correctly suggests the diagnosis of macroamylasemia without pancreatitis. Conversely, the presence of this sign should cause one (correctly) to switch the preferred diagnosis from aortic aneurysm to acute pancreatitis. (The Cupid's bow is not pathognomonic; it can be seen in other gastrointestinal conditions causing adynamic ileus.)

The epigastric bulge due to massive pericardial effusion is known as the *Auenbrugger sign*. This is the same Auenbrugger we met at the opera in Chapter 16.

The term "scaphoid" does not mean "unremarkable."

It means "shaped like a skiff or dinghy," that is, with the patient in the supine position, the sides of the boat are represented by the costal margins and the pubis and anterior iliac spines, while the bottom of the boat is represented by the abdominal wall sunken in under the effects of gravity. The significance of the scaphoid abdomen is that none of the above findings are seen, and in contrast to the situation with an obese abdomen, they would be seen if present.

Abnormalities of the Umbilicus

Normally, the umbilicus is located within 1 cm of the midpoint between the xiphoid and the symphysis pubis unless there are scars or a history of pregnancy carried to term. A deviation of more than 1 cm is often the clue that leads to an extremely thorough palpation.

Dr Frank Iber of Illinois notes that hepatomegaly of 1 or 2 years' duration will stretch the upper abdominal segment so that the distance between the xiphoid and the umbilicus is 2 cm longer than the distance from the umbilicus to the symphysis pubis. Such a downward displacement of the umbilicus can also be caused by ascites. In this case, it is known as the *Tanyol sign*.

Upward displacement of the umbilicus occurs in pelvic tumors, but the most common cause of upward displacement is still pregnancy.

Eversion or outward protrusion of a previously inverted umbilicus (Fig. 20-2) was thought to be a sign of chronic ascites, but there are false positives.

Respiratory Motion

The importance of examining the total abdominal surface for the phenomena of respiratory alternans and respiratory paradox (Macklem, 1986) is discussed in Chapter 16.

Additionally, Cope suggests looking for local limitations of respiratory movement of the abdominal wall in patients suspected of having an acute abdomen. For instance, in appendicitis with acute peritonitis, the right iliac region will very frequently remain selectively immobile during inspiration. In some cases of acute pancreatitis, the epigastric zone may be motionless. In generalized peritonitis, there is hardly any abdominal wall motion.

Markings

Ecchymoses

Subcutaneous blood from intraperitoneal or retroperitoneal hemorrhage may dissect to the skin overlying the flanks or to the

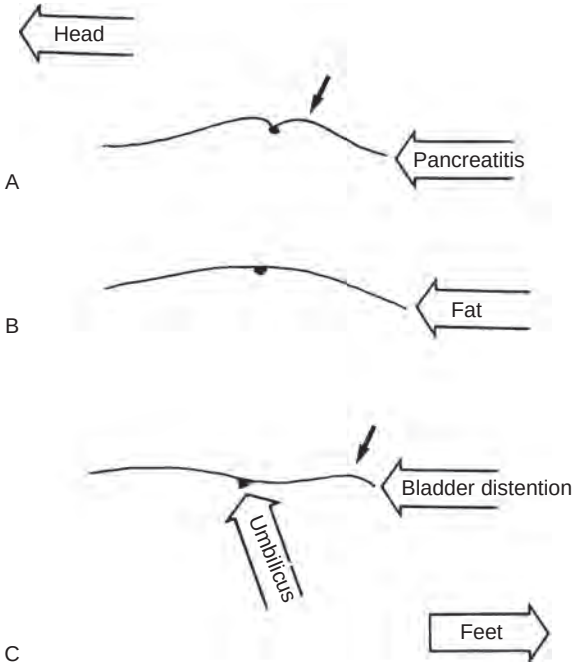

FIGURE 20-1 Lateral abdominal contours. **A:** Cupid's bow of pancreatitis. **B:** Fat. **C:** Bladder distention.

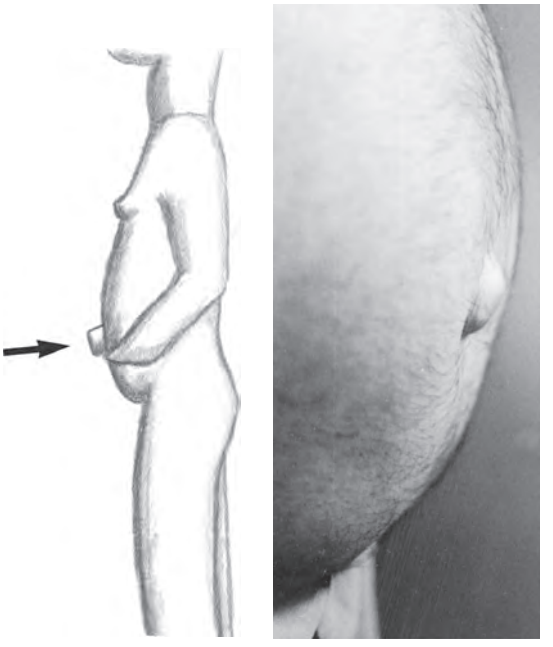

FIGURE 20-2 **A:** The everted umbilicus sign of chronic ascites. Drawing of an Igbo female tutelary spirit pit display in the Baltimore Museum of Art. **B:** A false positive everted belly button seen in an obese patient possessing a lax abdominal wall. There was no evidence of portal hypertension, hypoalbuminemia, liver disease, or ascites by any imaging procedure. Another false positive is shown in Fig. 20-4. (Courtesy of Dr Tim Rice of Missouri.)

anterior abdominal wall and cause a discoloration resembling a bruise or a subcutaneous injection site of heparin.

A periumbilical bruise is known as the *Cullen sign*, for the Baltimore doctor who described it in a case of ruptured ectopic pregnancy (Cullen, 1918). (This sign is to be distinguished from a green or jaundiced lesion at the umbilicus, which is the *Ransohoff sign* of a ruptured bile duct.) A similar discoloration in the flanks is called the *Turner sign* (not the Grey–Turner sign; there was no Dr Grey). This was described in a patient with acute pancreatitis by G. Grey Turner, 2 years after Cullen's report. In the same article, he described an earlier case of pancreatitis in which the bruising was periumbilical (Turner, 1920).

Preservation of the two different eponyms has obscured the fact that these are the same sign. The topographic location of the ecchymosis does not point to the etiology. In fact, the same pancreatitis patient may have "both" signs (Dickson and Imrie, 1984). Other locations have been at an appendectomy scar, a laparotomy scar, and umbilical and femoral hernias.

The sensitivity is less than 1% for ruptured ectopic pregnancy (Smith and Wright, 1935) and only 3% for acute pancreatitis, appearing late, between the second and sixth hospital day (Dickson and Imrie, 1984). Furthermore, it is not diagnostically specific, being also seen in ovarian cyst hemorrhage, strangulated umbilical hernia, bilateral acute salpingitis in the presence of intrauterine pregnancy, hemoperitoneum (not from ectopic pregnancy), hemorrhagic ascites from adenocarcinoma of the liver or renal sarcoma metastatic to the peritoneum (Smith and Wright, 1935), carcinoma of the liver (Mabin and Gelfand, 1974), strangulation of the ileum with hemorrhage, hypothyroid myopathy, and cirrhosis with portal hypertension (Kelley, 1961).

Striae

Abdominal striae are the longitudinal stretch marks seen in pregnancy, Cushing syndrome, and rapid gain and loss of weight. It has been taught that striae are usually red, but that they are purple in cases of idiopathic (noniatrogenic) Cushing syndrome because of the erythrocytosis resulting from the excess adrenal androgens.

Venous Pattern

Prominent venous patterns may be seen in portal hypertension or inferior vena caval syndrome (Fig. 20-3) or even in some aged normal persons (Snapper and Kahn, 1967). The clinician should note both the location of the veins and the direction of blood flow. In pure portal hypertension, the visible collateral veins tend to occur around the umbilicus. Those cephalad to the umbilicus drain in a cephalad direction, while those veins caudad to the umbilicus drain caudally. Thus, the direction of flow in pure portal hypertension is merely an exaggeration of the normal, but invisible, situation. Another way of describing this is that with portal hypertension, the direction of blood flow in superficial abdominal veins is away from the umbilicus (Bhaskar, 2009).

Perseus slew the Medusa by using his shield as a mirror so that he did not have to look at her directly and thereby share the fate of others who had become transfixed by her horrible appearance.

Her head (*the caput Medusa*) was surrounded by a bunch of snakes in place of hair. Before the age of surgery for portal hypertension, a rare patient with severe chronic portal hypertension could develop such large periumbilical venous collaterals that the veins stuck out like a bunch of snakes, the caput Medusa. However, caput Medusa should not be diagnosed just because there is a visible vein or two somewhere on the abdomen; otherwise this rare sign loses its diagnostic significance.

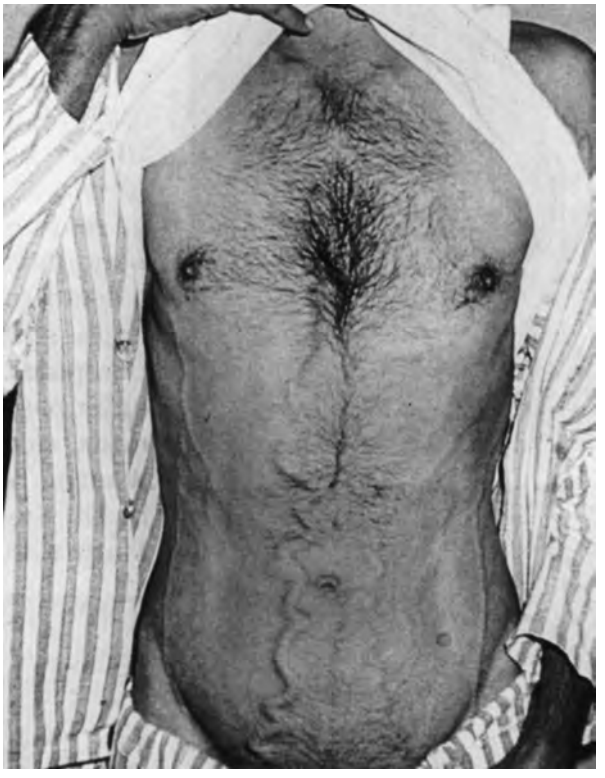

Figure 20-3 Inferior vena caval obstruction, resulting from carcinoma in the body of the pancreas. This is not a caput Medusa of portal hypertension, even though the individual veins look snakelike. The caput Medusa radiates out from the umbilicus. The veins of inferior vena caval syndrome simply pass the umbilicus on their north–south route. (Courtesy of Dr Syed A. Hoda of Louisiana and *Consultant Magazine*.)

In those rare cases of superior vena caval syndrome (see Chapter 19) in which collaterals can be found in the upper abdomen, the normal direction of drainage is reversed, with the veins superior to the umbilicus actually draining caudally.

In cases of pure inferior vena caval syndrome, the collateral veins tend to appear more laterally in the flanks. They drain in a cephalad direction regardless of whether they are above or below the umbilicus. In the inferior vena caval syndrome, it is more difficult to determine the direction of flow by stripping the veins and seeing in which direction they fill than it is in portal hypertension (Missal et al., 1965).

(In chronic liver disease with portal hypertension and ascites compressing the inferior vena cava, there may be a mixed picture in which the veins are lateral and periumbilical. The venous flow is cephalad in the veins superior to the umbilicus but may be indeterminate in the veins inferior to the umbilicus.)

In cases in which the direction of venous flow cannot be determined, the consultant should be prepared to discount the finding of flank veins as being indicative of inferior vena caval disease, especially if there are no other signs of such disease. However, if one has previously examined the patient and that venous pattern has just recently appeared, it is in itself collaborative evidence of inferior vena caval disease.

Self-assessment

Before reading the legends, write down your diagnosis for the patients pictured in Figs. 20-4 and 20-5.

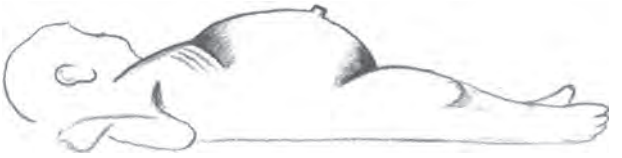

Figure 20-4 Drawing of the lateral profile autopsy photograph of Pepper's 1901 case of neuroblastoma metastatic to the liver. Notice that the tumorous liver is holding the abdomen up, whereas ascites alone would fall into the flanks in response to gravity with the patient supine. Note also the protuberant umbilicus.

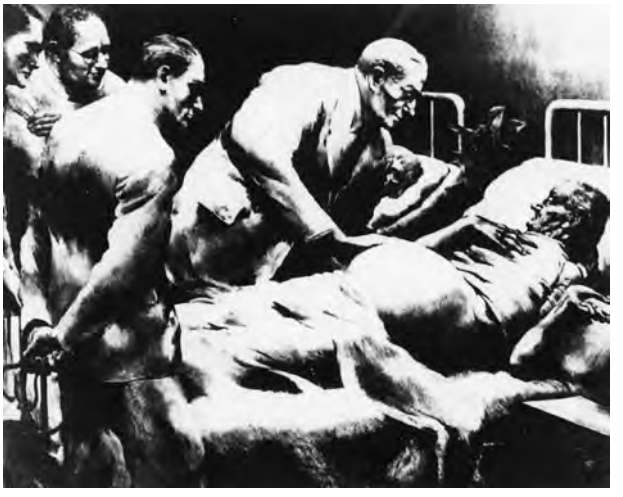

Figure 20-5 Ward Rounds, lithograph by Robert Riggs. What is your diagnosis? Three that have been offered are pregnancy, ovarian cyst, and ascites. What do you think of each of these? (Appendix 20.1.) What is the patient holding in her left hand? (From Medicine and the Artist [Ars Medica], with permission of the Philadelphia Museum of Art.)

Palpation

The palpation of the abdomen should be done in an orderly sequence, beginning with the right upper quadrant and proceeding to the left upper quadrant, the left lower quadrant, the right lower quadrant, and the periumbilical area, with particular attention to the aorta (see Chapter 18). If the patient is complaining of pain, the order should be altered so that the painful area is examined last.

To help the patient relax the abdominal musculature, it is often helpful to have him flex his knees and hips and rest his soles on the bed. Have him place his hands on his chest (as recommended by Dr Thomas Dorman); this has the added advantage of getting them out of the examiner's way.

The palpation of specific organs, such as the liver, gallbladder, spleen, and kidneys, is discussed in detail in their respective sections later in the chapter.

One also palpates for masses. Colonic carcinoma may present as a palpable mass in any one of the four abdominal quadrants. Pseudocolonic tumors or phantom tumors due to stool are frequent in the left lower quadrant, but less frequent in the left upper quadrant. Wiener and Nathanson (1976–1977) state that such phantom tumors may also occur in the right colon.

A giant phytobezoar in the left hypochondrium felt like a head of lettuce (iceberg or Boston, not Romaine).

Palpating the Abdomen in the Presence of Abdominal Pain

A Note on the Female Patient

It is assumed that you will take a careful menstrual history at the beginning of every encounter with every female patient, particularly if she has abdominal pain. This point cannot be overemphasized. Many conditions covered in Chapter 22 need to be kept in mind as you proceed with the examination, the most perilous one being an ectopic pregnancy.

Local Rigidity (Local Guarding)

Local muscle rigidity over an area of peritonitis is frequently present (but by no means invariable). In the most extreme case, the particular section of the abdominal wall is persistently stiff and will not move with respiration. In the less extreme case, the muscle stiffens almost as soon as the hand touches the skin. In the least case, the rigidity occurs only when the fingers are pressed in more deeply. Take care to exclude the rigidity due to patient apprehension or to a rough or cold examining hand. Cope emphasizes that there are many false negatives and that an appendix may be on the verge of rupturing into the peritoneal cavity even though the abdominal wall is flaccid (Silen, 1979).

For the early diagnosis of the acute abdomen, Cope suggests the most likely (not the only) possibilities, as listed in Table 20.1.

Underdiagnosed conditions found at autopsy in patients presenting with an acute abdomen include mesenteric thrombosis, peritonitis, perforated peptic ulcer, acute pancreatitis, empyema of the gall bladder, pulmonary embolus, and acute pyelonephritis (Cameron and McGoogan, 1981).

Some causes of intermittent abdominal pain are listed in Table 20.2.

Induced Guarding

One portion of the interview can be combined with a physical maneuver in the differential diagnosis of abdominal pain. Ask the patient to rate his abdominal pain on a scale of 1 to 10 (first baseline). Second, press over the area of tenderness to see by how many points (if any) the pain increases with hand pressure. Then obtain a third, postpressure pain rating (second baseline). Finally, have the patient lift his head from the bed and put his chin on the chest to induce voluntary guarding. Press again and get a fourth rating. This is called the *Carnett maneuver*.

Caveat

It is essential that the pressure be the same each time. This can be difficult to ensure. One way is to allow one's fist to fall on the abdomen each time from the same height. Of course, one must apologize to the patient for inducing pain, explaining that it is part of the examination. Alternately, one can place a blood pressure cuff and sphygmomanometer on the abdomen with the cuff partly inflated and the manometer screw valve well sealed. Press to produce the same amount of pressure each time.

Interpretation

Pain of intraperitoneal origin will be lessened by the maneuver of voluntary guarding, which protects the peritoneal contents.

TABLE **20.1** *Differential diagnosis of abdominal pain*

Periumbilical pain without signs elsewhere
- Acute appendicitis
- Acute obstruction of the small bowel
- Acute gastritis
- Intestinal colic
- Acute pancreatitis

Severe abdominal pain with rigidity of the entire abdominal wall and prostration
- Perforated peptic ulcer
- Other gut perforations
- Dissecting aneurysm

Tenderness and rigidity in the right upper quadrant
- Leaking duodenal ulcer
- Acute cholecystitis
- Appendicitis with a high appendix
- Pleurisy

Tenderness and rigidity in the left upper quadrant
- Pancreatitis
- Perforated gastric ulcer with a subphrenic abscess
- Leaking diverticulosis
- Ruptured spleen
- Leaking aneurysm of the splenic artery
- Acute perinephritis

Tenderness and rigidity in the right lower quadrant
- Appendicitis
- Leaking duodenal ulcer
- Acute pyelonephritis
- Regional ileitis
- Inflamed ileocecal glands
- Inflamed Meckel diverticulum
- Cholecystitis with a low gallbladder
- Pelvic inflammatory disease
- Biliary peritonitis

Tenderness and rigidity in the left lower quadrant
- Diverticulitis
- Cancer of the colon
- Pelvic peritonitis spreading upward

From Silen W, ed. *Cope's Early Diagnosis of the Acute Abdomen.* 15th Ed. New York: Oxford University Press; 1979, with permission.

In such patients, the fourth rating should be less than the second. Pain originating in the abdominal wall, peripheral nerves, or higher centers will not be ameliorated and may be increased by this maneuver (a positive Carnett sign). Causes of such pain include abdominal wall hernia, nerve entrapment syndromes, myofascial pain syndromes, rectus sheath hematoma, and rib tip syndrome (Pasricha, 2003). The test has a positive likelihood ratio (LR) for peritonitis of 0.1 (95% CI 0, 0.7) and a negative LR of 1.9 (95% CI 0.9, 4.4) (McGee, 2001).

TABLE **20.2** *Some causes of intermittent abdominal pain*

Physical or obstructive
Cholelithiasis
Intermittent bowel obstruction
Intussusception
Internal hernia
Abdominal wall hernia
Metabolic or genetic
Acute intermittent porphyria
Familial Mediterranean fever
Neurologic
Abdominal epilepsy
Abdominal migraine
Diabetic and other forms of radiculopathy
Nerve entrapment syndromes
Miscellaneous
Endometriosis
Heavy metal (lead) poisoning
Mesenteric ischemia
Acute recurrent pancreatitis

Pasricha PJ. Approach to the patient with abdominal pain. In: Yamada T, Alpers DH, Laine L, et al., eds. *Textbook of Gastroenterology.* 4th Ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2003, with permission.

Alternate Method

In a modification of the Carnett maneuver, the guarding is induced by having the patient cross his arms while supine and then sit up. The abdomen is palpated as the patient reaches halfway between recumbent and sitting positions, the point of maximal abdominal musculature contraction and guarding.

This test was studied in a group of patients admitted to the emergency ward with localized abdominal pain (Thompson and Francis, 1977). (Patients with abdominal rigidity, in whom the test is useless and inappropriate, and those suspected of having an intra-abdominal abscess, in whom the test is needless and possibly dangerous, were excluded.) A positive test was reduction of abdominal wall tenderness at midway palpation. A negative test was worsening of pain at this point.

The predictive value (PV) of a positive test and the sensitivity were both 99% for appendiceal abscesses, cholecystitis, bowel obstruction, ruptured ovarian cyst, ureteral colic, urinary tract infection, and so forth. The PV of a negative test for patients who were "undiagnosable" was 96%. (Almost half of the latter group went to a negative surgical exploration.)

Rebound and Referred Tests

The Blumberg Sign (Rebound Tenderness)

The Blumberg sign is a general test for pain for picking up early peritonitis in any area.

A Method. Having palpated the tender areas as deeply as circumstances permit, the palpating hand is abruptly withdrawn. The previously stretched abdominal musculature will then spring back into place carrying with it the peritoneum. If the peritoneum is inflamed, the patient will wince or cry out. This sign is often called *rebound tenderness*. Bailey (Clain, 1973) correctly emphasizes that this test is quite unnecessary in patients with undoubted involuntary rigidity.

The Referred Rebound Test

Cope does not recommend the rebound tenderness test (the Blumberg sign, first method) because he considers it cruel and not useful. But this modification may be useful with patients suspected of being not completely cooperative or precise in reporting their sensations.

A Method

1. If the patient has, for example, pain in the right upper quadrant, which was unconvincing to previous examiners, press slowly and deeply into a place where there is no pain, such as the left upper quadrant.
2. Then release the pressure suddenly, as if to test for rebound tenderness in the left upper quadrant, and ask, "Does that hurt?"

Interpretation

If the patient points to the right upper quadrant, at the same location as before, as the site of the pain while denying any pain in the left upper quadrant, the test is positive. That means that the patient is reporting accurately or else is an extremely clever and well-read dissembler.

The test is useful only if positive. A negative test does not prove that the patient has not been accurately reporting the original right upper quadrant pain.

Cope's Method

It is useful to cross-palpate from the opposite side. For example, if you are evaluating pain in the left upper quadrant, press in the right upper quadrant and slowly move your palpating hand across the midline. If pressure in the right upper quadrant produces pain in the left upper quadrant before your hand crosses the midline, this tells you that the pain is coming from an abdominal condition and is not thoracic or referred. This also works well in the lower quadrants (Silen, 1979).

A Second Method of Blumberg

Blumberg also pressed in the left iliac fossa, and if the patient complained of pain anywhere in the lower abdomen (i.e., referred pain), he used this as evidence supporting the provisional diagnosis of acute appendicitis, although the sign is also positive in other acute abdominal conditions.

The Rovsing Sign

Rovsing also pressed on the left iliac fossa. If the direct pressure there produced referred pain in the right iliac fossa, the likelihood of appendicitis was increased. It is also a sign of distention of the colon (T. Dorman, *personal communication*, 1998). This is not a perfect test; there are both false positives and false negatives.

Note that the above assumes that the examiner is standing at the right side of the examining table and examining the patient with

the right hand. This assumption is traditional in medicine but not very important. If you feel more comfortable beginning on the left and examining with the left hand (or with the right hand for that matter), then perform the examination that way. If you modify the text to accommodate your own preference, knowledge of basic anatomy will permit you to alter the instructions *mutatis mutandis*.

Hyperesthesia

Hyperesthesia to light touch in the referred dermatomes may sometimes occur in acute abdominal conditions. Patients with appendicitis may have hyperesthesia in the anterior right lower quadrant.

Hyperesthesia in the region shown in Fig. 20-6 (the Boas sign) is a sign of gallbladder disease. This test is especially useful in patients who are schizophrenic or demented. They will grimace if the test is positive, even though they may not be able to report their experiences verbally. Few patients know about this test, so if it is positive, any suspicion of malingering should be discarded. Unfortunately, the Boas sign has a sensitivity of less than 7% (Gunn and Keddie, 1972).

In diabetic patients, thoracoabdominal neuropathy may mimic the symptoms of intra-abdominal pathology such as gallbladder disease or appendicitis. There may be hyperesthesia in a dermatomal distribution (Harati and Niakan, 1986). Another consideration in the differential diagnosis of abdominal pain accompanied by hyperesthesia is herpes zoster. The characteristic skin eruption may not appear for several days.

Abdominal Wall

Sometimes one notices a different consistency to the abdominal wall on deep palpation. This consistency has been variously described as "doughy," "grainy," "stringy," and "glandular." The tissue feels a bit like postmenstrual breast tissue, which has lost some of its water content but is still glandular. The most benign cause of this sensation is residual fat following a period of weight loss, but granulomatous peritonitis, especially that caused by tuberculosis, may also cause this consistency, comparable to dough on a breadboard. And sometimes this sensation is a manifestation of peritoneal metastases, especially of malignant melanoma.

Peritoneal metastases may also feel discrete or lumpy. Plaques of "fatty" or glandular-feeling material are separated by areas of completely normal consistency a few centimeters in width. The mapped-out sensation of this abnormal resistance to palpation would resemble an abstract expressionist painting (as by Jackson Pollock), in which paint had been thrown on the canvas and allowed to drip, leaving clear spaces in between.

A Note on the McBurney Point

Classically, the tenderness of acute appendicitis is localized over the McBurney point (see the dotted line in Fig. 20-7) until rupture and generalized peritonitis supervene. This valuable point has been misidentified in so many works that McBurney's own description is cited (McBurney, 1889):

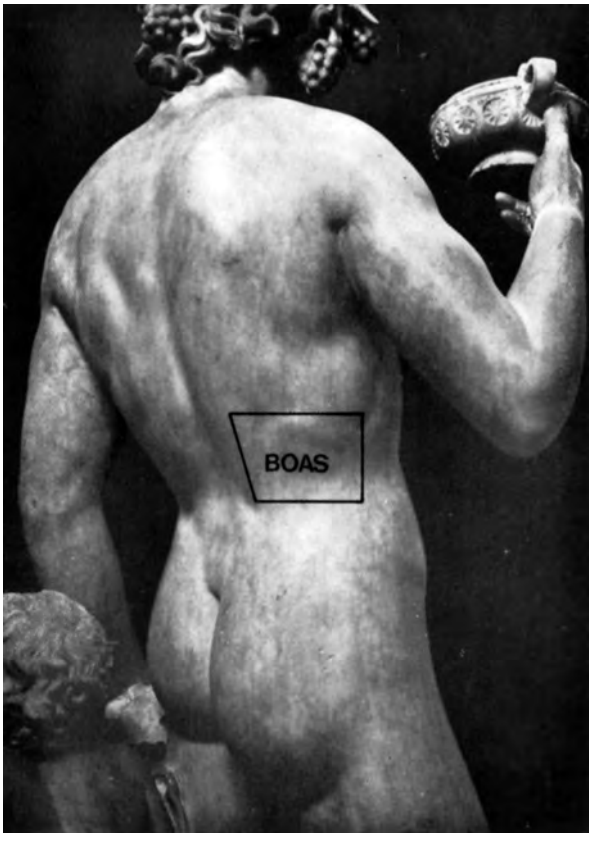

Figure 20-6 Rectangle encloses area of possible hyperesthesia in gallbladder disease. (Bacchus, by Michelangelo.)

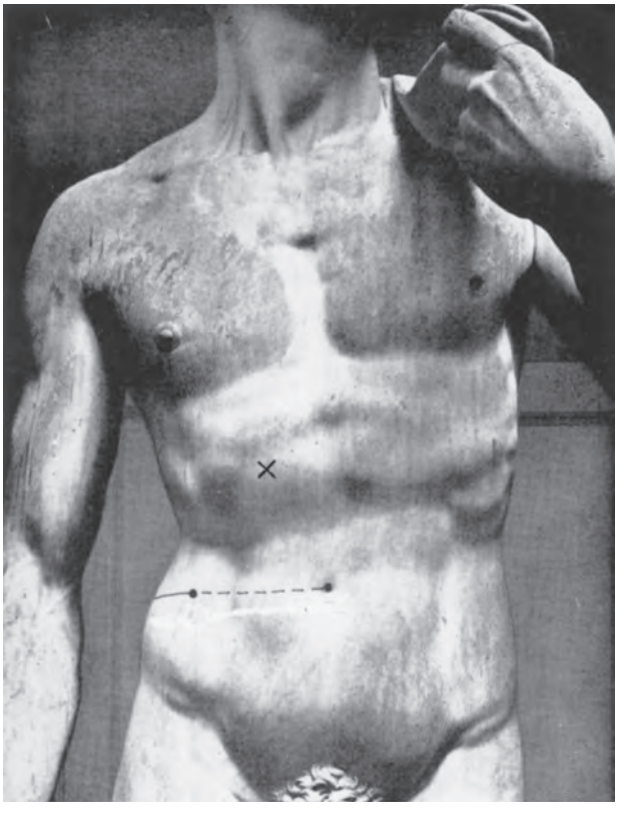

Figure 20-7 The McBurney point is on the dotted line, 1.5 to 2 in. from the anterior superior iliac spine. The area to check for the Murphy sign (see text) is marked by the "X." (David, by Michelangelo.)

> And I believe that in every case the seat of the greatest pain, determined by the pressure of one finger, has been very exactly between 1.5 and 2 in, from the anterior spinous process of the ilium on a straight line drawn from that process to the umbilicus. This may appear to be an affectation of accuracy, but, so far as my experience goes, the observation is correct.

Often, the patient with acute appendicitis may be able to localize his pain precisely with one finger, especially after a cough or the Valsalva maneuver. With aberrant locations of the appendix (such as retrocecal), the tenderness will not be in the expected location.

Tenderness at the McBurney point is the best single test for detecting appendicitis, with a positive LR of 3.4 (95% CI 1.6, 7.2) and a negative LR of 0.4 (95% CI 0.2, 0.7) (McGee, 2001).

Study Question: *If the patient in Fig. 20-7 actually has a perinephric abscess, what side is it on? (See Appendix 20.2.)*

Slipping-rib Syndrome

Slipping-rib syndrome, diagnosed by the "hooking maneuver" described in Chapter 16, may present with upper abdominal pain aggravated by certain postures and movements and relieved by a local anesthetic injection. In one gastroenterologic clinic, it was diagnosed in nearly 5% of patients, most commonly in those who had undergone a number of negative investigations (Wright, 1980). This maneuver might be worth considering in "undiagnosable" patients—with the caveat that it misdiagnosed a case of abdominal abscess in a patient with Crohn disease.

FIGURE 20-8 Upright abdominal plate of a patient who had a hollow percussion note in his right midaxillary line where liver dullness would have been expected. Notice the air under the diaphragm.

Percussion

There should always be hepatic dullness in the right midaxillary line, except in the presence of free air under the diaphragm, which produces resonance (Silen, 1979). The availability of upright films of the abdomen (Fig. 20-8) has made this a rare maneuver in the US.

Subphrenic abscess, an intra-abdominal disease, may be diagnosed by percussion of the chest (see Chapter 16, Fig. 16-4).

A distended, tympanitic abdomen is a sign of bowel obstruction.

The percussion of specific organs is discussed later in this chapter.

Auscultation

Bowel Sounds

Currently, this is a surprisingly controversial subject. Some gastroenterologists see no point in listening for bowel sounds, whereas others with gray beards find it valuable. Both groups would undoubtedly agree with the following consensus statements.

1. If you wish to hear bowel sounds, you should apply your stethoscope to the abdomen *before* performing palpation or percussion because these may disturb the peritoneal contents into silent pouting. (However, after percussion, the auscultation should be recorded in the case record in the usual sequence.)
2. As far as the routine screening physical examination is concerned, auscultation of the bowel sounds is of low yield.

A Method

1. Warm the chest piece of your stethoscope by rubbing it briskly in the palm of your hand.
2. Lightly rest the chest piece of the stethoscope in each of the four quadrants of the abdomen. Listen for bowel sounds. If no bowel sounds are heard, enter this fact in the case record, along with a note about the length of time that you listened. To hear the tinkles and rushes[1] of small bowel obstruction, which occur between periods of silence every 10 to 20 minutes (during episodes of cramping abdominal pain), you must listen for 20 minutes! Major (Delp and Manning, 1975) cleverly makes the suggestion that if there is anything to suggest the presence of a small bowel obstruction, one should begin the auscultation of the abdomen during the interview. Remove one of the stethoscope earpieces from your ear to listen to the patient's words. When the patient interrupts his story because of abdominal pain, switch your attention to the ear that is connected to the stethoscope.
3. Feel free to modify this method according to the comments below.

Interpretation

No particular type of bowel sounds, or absence of the same, is diagnostic of any one condition, except for the very high-pitched tinkles and rushes of small bowel obstruction.

[1] "Tinkles" are bowel sounds of musical timbre occurring one to two octaves higher than normal. Some require them to have a frequency above 512 Hz (high C) (Dennis, 1954). "Rushes" are bowel sounds accelerated to at least three times normal speed.

The complete absence of sounds can be a sign of very advanced intestinal obstruction, a perforated viscus, intestinal ischemia, secondary ileus, or primary disease of the bowel, or it can be viewed as a normal acoustic occurrence between episodes of normal bowel motility.

Increased peristalsis can occur with any obstruction from the pylorus to the cecum, but also occurs during diarrhea of any etiology.

Murmurs

Arterial bruits in the abdomen are discussed in Chapter 18. It is rare for such bruits to have such a lengthy diastolic spillover that they sound continuous, and true continuous murmurs, such as those resulting from an arteriovenous fistula in the splanchnic circulation, are uncommon. Most continuous sounds in the abdomen are of venous origin.

Venous Hums

A high-pitched continuous "hepatic" venous hum, probably coming from the inferior vena cava and radiating along the line of that vessel (Bloom, 1950), is heard in less than 4% of normal persons (Rivin, 1972), more often in the presence of anemia. It is usually heard to the right of the umbilicus, and it has the same physiology as the cervical venous hums discussed in Chapter 19. Specifically, it diminishes or disappears during the forced exhalation phase of the Valsalva maneuver (Hardison, 1977).

A similar high-pitched venous hum of more variable radiation (see Chapter 17) is also heard in portal hypertension and in fact is considered diagnostic of that condition (Hardison, 1977). Usually, it is heard over the xiphoid or the umbilicus; more than one focus of sound may occasionally be present (Bloom, 1950). This hum, which has been called the *Cruveilhier–Baumgarten murmur*, originates from the paraumbilical anastomotic veins. (The umbilical vein is *not* recanalized in this syndrome [LaFortune et al., 1985], despite statements to the contrary.) Transmission to the precordium is generally by way of subcutaneous varices in the chest wall or dilated internal mammary veins (Bloom, 1950).

Unlike the hum sometimes heard in normal persons, the Cruveilhier–Baumgarten murmur (or hum) becomes *louder* during the forced expiratory phase of the Valsalva maneuver (Hardison, 1977). However, during normal respiration, it becomes louder during early inspiration but softer during later inspiration (Cheng et al., 1954). (Because there are those who believe that an increase in such a murmur during inspiration results from compression of the splenic vein and signifies no more than splenomegaly, it is hard to know the exact significance of these changes, especially considering that splenomegaly itself will be a frequent concomitant of portal hypertension.) Although any murmur that significantly diminishes or disappears with epigastric pressure is undoubtedly a Cruveilhier–Baumgarten murmur, not all Cruveilhier–Baumgarten murmurs will have this unique sign (Hardison, 1977). (Also see Table 17.5.) One constant is that the murmur increases or appears 30 to 60 minutes after an oral glucose load (Cheng et al., 1954; Ramakrishnan, 1978).

How was this latter phenomenon discovered? In the old days, it was convenient to make the diagnosis of portal hypertension by comparing the glucose content of the paraumbilical vein with that of a peripheral vein 30 to 60 minutes after a 50-g oral glucose load. The markedly higher values (20 to 50 mg per dL) in the paraumbilical vein showed convincingly that it was not simply a peripheral vein but an integral part of the portal venous system. During such a test, someone must have listened to the hum and made the observation. (There are still hundreds of such observations waiting to be made right now.)

Bloom claims that the paraxiphoid–umbilical hum is almost pathognomonic of hepatic cirrhosis, making liver biopsy unnecessary for making that diagnosis. In fact, he states that the sign indicates the presence of hepatic fibrosis even if such special investigations are negative (Bloom, 1950).

Rubs

Friction rubs over the liver can be heard in hepatoma, cholangiocarcinoma, and 10% of cases of metastatic carcinoma (Fenster and Klatskin, 1961). They also occur after a biopsy (Naylor, 1994). Rubs are less frequent in inflammatory conditions including pyogenic abscess, viral hepatitis, alcoholic hepatitis, cholecystitis, tuberculous peritonitis, and perihepatitis secondary to lupus erythematosus or gonococcal infections. If a murmur coexists, diagnose neoplasia, not inflammation (Sherman and Hardison, 1979).

It should not be surprising that it is also possible to auscultate a rub over an inflamed gallbladder or a splenic infarct.

Special Maneuvers

The Valsalva Maneuver

After a 20-second vigorous Valsalva maneuver, the patient with an acute abdomen will often be able to point to a specific area of tenderness. Identifying this area first allows one to plan a strategy that minimizes discomfort to the patient, permitting a more adequate (as well as more humane) examination. Pathology in the hip can confound the results (see Chapter 25 and Fig. 25-20).

The Obturator Test

The purpose of the obturator test is to move the obturator muscle passively, an action that normally produces no pain. However, if the obturator muscle is inflamed because of pathology of a neighboring viscus, pain is produced.

A Method

1. With the patient supine, flex the thigh and rotate it fully inward (Fig. 20-9).
2. Repeat on the opposite side.

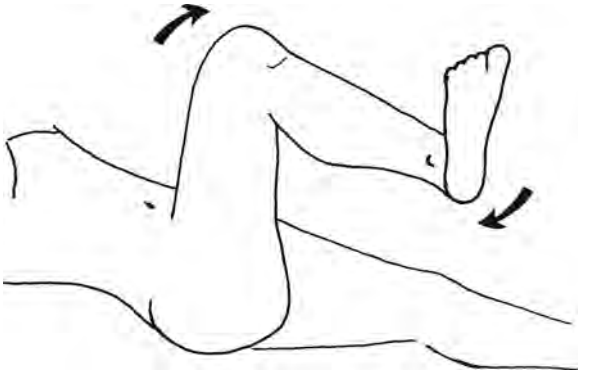

FIGURE **20-9** The obturator test. Standing lateral to the leg, pull the ankle toward you and push the knee away from you.

Interpretation

This test is positive if the inward rotation produces pain, usually referred to the hypogastrium (i.e., the central inferior abdomen where the bladder is located).

In appendicitis, the test is positive on the right but not on the left. It can be positive on either side in the case of pelvic abscesses or pelvic hemorrhage. It can also be positive if there is pus in the pelvis, even if the pus came from above.

The Reverse Psoas Maneuver

The reverse psoas maneuver, also called *Cope's iliopsoas test*, is useful in detecting psoas irritation from appendicitis, psoas abscess, or psoas hematoma.

A Method

1. Have the patient roll onto his left side. Hyperextend the right hip (away from the position that the patient would naturally assume with a right psoas sign—see the drawing of St Sebastian, Fig. 5-2) to see whether pain can be elicited.
2. Repeat on the other side to check for nonappendiceal left psoas lesions.

Detecting a Ventral Hernia

If the supine patient places his chin on his chest, or attempts a sit-up with his hands folded on his chest, he will need to contract his rectus abdominus muscles, thereby making an abdominal ventral hernia more apparent to inspection and palpation.

A Valsalva maneuver may distend a hernia that can be seen more readily than felt.

Auscultation After Tube Placement

Instilling air into a feeding or gastric tube while listening distally, over the stomach, for a hissing or bubbling sound has been recommended as a means to check tube placement. When auscultation was compared with radiography to check for placement of a weighted enteral tube, sensitivity was 98% but specificity was an alarmingly low 6.3%, with a negative PV of 50%. Of 16 placements that were not gastric, 15 were incorrectly identified as being gastric by auscultation. Aspiration of fluid to check for pH was recommended in all cases, with radiography to check for tube placement unless the pH was less than 4.0 (Neumann et al., 1995).

Gary Albers of Missouri told of a comatose patient into whom a nurse passed a nasogastric tube and, hearing the expected bubbling sound near the stomach, began feedings. Soon the patient developed a left-sided pneumonia with empyema. Investigation revealed that the feeding tube had been passed into the left lower lobe of the lung and through the pleura into the subpleural space.

One should listen over the stomach after an endotracheal tube has been placed. A hissing or bubbling sound means that you have intubated the esophagus and must correct the problem immediately (also see Chapter 16).

The Succussion Splash

The same principles described in Chapter 16 apply to gastric outlet obstruction or any other abdominal condition in which a nonviscous liquid forms the lower portion of a gas–liquid interface. Note that there must be a large amount of the gas over the liquid phase. Also, the patient must be in a condition that permits him to be passively shaken, and the splash must be located sufficiently close to the abdominal wall that it can be detected with a stethoscope.

Flat and upright films are superior to the succussion splash for finding air–fluid levels. However, the succussion splash, while an insensitive maneuver, is cheap and quick. Because there are many normally occurring gas–fluid interfaces in the abdominal cavity, the succussion splash is less specific than in the chest, where it is always abnormal (see Fig. 16-11).

The Hannington–Kiff Sign

The Hannington–Kiff sign for strangulated obturator hernia is given in Chapter 26.

Synthesis

Ascites

The presence of ascites has great diagnostic as well as prognostic importance. It raises the index of suspicion for a number of rather uncommon disorders; see the differential diagnosis listed in Table 20.3. The diagnosticity of various findings that

TABLE **20.3** *Differential diagnoses of ascites*

I. Elevated hydrostatic pressure
  A. Cirrhosis
  B. Congestive heart failure
  C. Right-sided cardiac valvular disease
  D. Constrictive pericarditis
  E. Inferior vena cava obstruction
  F. Hepatic vein obstruction (Budd–Chiari syndrome)
II. Decreased osmotic pressure
  A. Nephrotic syndrome
  B. Protein-losing enteropathy
  C. Malnutrition
  D. Cirrhosis or hepatic insufficiency
III. Fluid production exceeding resorptive capacity
  A. Infections
    1. Bacterial
    2. Tuberculosis
    3. Parasitic
  B. Neoplasms
    1. Carcinomatosis with peritoneal seeding
    2. Benign ovarian tumor (Meigs syndrome)
  C. Pancreatic ascites (leaking pseudocyst)
  D. Eosinophilic gastroenteritis
IV. Chylous ascites (lymphatic obstruction)
  A. Tumor
  B. Trauma
  C. Congenital anomaly
  D. Infection (filariasis and tuberculosis)

From Williams JW Jr, Simel DL. Does this patient have ascites? How to divine fluid in the abdomen. *JAMA*. 1992;267:2645–2648, with permission.

have been investigated in a comparative fashion is given in Tables 20.4 and 20.5.

Inspection

Patients with ascites are said to have a protruding abdomen like certain depictions of the Buddha (as well as some umbilical signs; see earlier in this chapter). Unfortunately, many persons who are obese or who have abdominal muscular hypotonia may have such an appearance.

Dr Iber of Illinois states, "Flank bulge in the supine patient is clearly distinguishable from the flab of fatness and indicates ascites often when other methods are equivocal. The fluid distends only as far back as the peritoneum goes; fat goes further back." But less experienced examiners have reported difficulty in making the distinction (Tables 20.4 and 20.5, "Bulging flanks").

TABLE **20.4** *Sensitivity and specificity of clinical findings suggesting ascites (ultrasound as the gold standard)*

	Sensitivity			Specificity[a]		
Sign	Cummings et al. (1985)	Williams and Simel (1992)	Cattau et al. (1982)	Cummings et al. (1985)	Williams and Simel (1992)	Cattau et al. (1982)
Increased girth by history	—	0.87	—	—	0.77	—
Ankle swelling by history	—	0.93	—	—	0.66	—
Bulging flanks	0.72	0.93	0.78	0.70	0.54	0.44
Flank dullness	—	0.80	0.94	—	0.69	0.29
Shifting dullness	0.88	0.60	0.83	0.56	0.90	0.56
Fluid wave	0.53	0.80	0.50	0.90	0.92	0.82
Puddle sign	—	0.43	0.55	—	0.83	0.51
Peripheral edema	—	0.87	—	—	—	0.77
Roentgenogram	—	—	0.50	—	—	—
Paracentesis	—	—	0.67	—	—	—

[a]False positives: Tests for ascites, being tests for free fluid in the peritoneum, could theoretically have false positives due to any cause of mobile fluid, such as blood, succus entericus (after a perforation), or fluid in an obstructed loop of intestine. But hemorrhage, perforation, or obstruction sufficient to cause enough such fluid to produce a false positive should be easily diagnosed on other grounds.

TABLE **20.5** *Likelihood ratios for the clinical examination for ascites*

	Likelihood ratio positive			Likelihood ratio negative		
Sign	Cummings et al. (1985)	Simel et al. (1988)	Cattau et al. (1982)	Cummings et al. (1985)	Simel et al. (1982)	Cattau et al. (1982)
Increased girth by history	—	4.16	—	—	0.17	—
Ankle swelling by history	—	2.80	—	—	0.10	—
Bulging flanks	2.4	2.0	1.4	0.4	0.1	0.5
Flank dullness	—	2.6	1.3	—	0.3	0.2
Shifting dullness	2.0	5.8	1.9	0.2	0.5	0.4
Fluid wave	5.3	9.6	2.8	0.5	0.2	0.6
Puddle sign	—	2.6	1.1	—	0.7	0.9
Peripheral edema	—	3.8	—	—	0.2	—

Palpation

There are two basic techniques for palpating fluid in the flanks. The first of these is the well-known fluid wave (Fig. 20-10).

A Method

1. With the patient supine, place one hand on the lateral aspect of the patient's abdomen (flanks) between the costal margin and the ilium in the anterior axillary line. (Because of the differences in human anatomy from subject to subject, I advise the beginner to pretend that the peritoneal cavity is one-fourth full of water and that the water is to be sloshed with the right hand so that it ripples in a wave striking the left flank where the left hand and fingers are prepared to sense the impact. The hands should be placed appropriately.)
2. Have the patient or an assistant place the ulnar surface of one hand above the umbilicus in the craniocaudal dimension, wedging it into the abdomen. This procedure prevents false positives produced by the percussing hand's thumping the body wall so hard that the shock wave ripples over the anterior abdominal wall to the opposite side.
3. Thump with one hand and palpate with the other. You will sense a shock wave if sufficient ascites is present.
4. As a check for artifacts or unilateral insensitivities of the examiner, let the palpating hand now percuss and vice versa.

When properly performed, this test is of high PV (>70%) for ascites if positive. But obviously, it is of limited sensitivity because it requires sufficient fluid in the peritoneal cavity to make a wave (Table 20.4).

A fluid wave can be detected in the erect position in some patients in whom it is inapparent in the supine position (Guarino, 1986).

A Second Method

This method was learned by watching Dr Jack Myers, University of Pittsburgh. It seems to have the same diagnostic outcome as checking for a fluid wave, but it has the advantage of not requiring an awake patient or an assistant.

1. Place the patient in a supine position.
2. Lean over the patient and place your hands, with the volar surfaces toward you and the dorsal surfaces touching the bed, behind his presumably bulging flanks.
3. Quickly flip up the flanks about 3 or 4 in. Note whether you can feel fluid falling back into the bulging flanks.

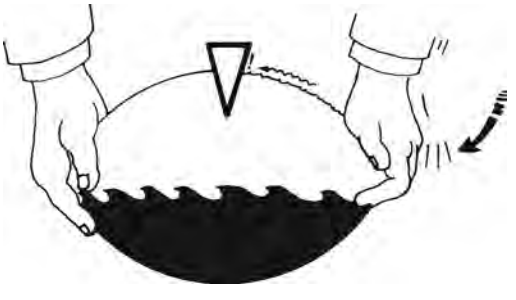

Figure 20-10 Diagrammatic representation of the fluid wave. The wedge represents the hand of the patient or assistant, which intercepts any anterior wall vibrations.

Percussion

There are two percussive techniques.

Periumbilical Hyperresonance

With the patient supine, percuss the abdomen, demonstrating that hyperresonance is present only around the umbilicus. Supposedly, with severe ascites, the gas-filled loops of bowel will all float to the top.

Shifting Dullness

A Method

1. Have the patient lie in the supine position.
2. Percussing circumferentially from above to below, mark the point at which the percussion note becomes dull, if you can find one. This is actually the test for flank dullness (Tables 20.4 and 20.5). If this point of dullness represents fluid, there should actually be a series of such points (a line) of dullness, parallel to the floor. Mark this line. (Fig. 20-11.)
3. Do the same thing on the other side. If you have correctly percussed out the surface of the ascitic fluid, this line should be in a position corresponding to the one on the other side.
4. Roll the patient over onto the right side.

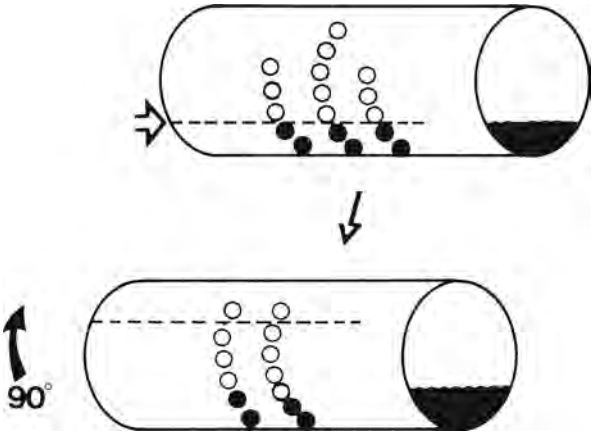

Figure 20-11 The semeiophysiology of shifting dullness can be best understood by likening the ascitic patient to a wine barrel that can be percussed and rolled. The *open circles* (○) represent a relatively resonant percussion note; the *solid circles* (●) represent a dull or flat note. The line of demarcation (*arrow*) between the resonant and the dull areas should correspond to the fluid level in the barrel. Of course, it would not be unusual to get dullness in a person as one neared the inferior surface of the body, which is lying supine in bed, because of the musculoskeletal structures on the dorsal surface of the body. (Furthermore, as was pointed out in Chapter 16, the simple apposition of the body to the bed will cause dullness.) In order to demonstrate fluid, we need to show that the dullness shifts. In the lower half of the figure, the barrel is rotated toward the right lateral decubitus position. Actually, the barrel has been rotated less than the 90-degree rotation noted, for ease of illustration. Note that the original line of dullness, marked on the barrel with a dashed line, has now rotated superiorly. The original percussion markings have been erased, and they have been replaced with new ones obtained with the barrel in the rotated position. It should be obvious from this illustration that it is very difficult to detect small amounts of fluid with this technique.

5. Percuss the left (superior) flank dorsal to the line you had marked. If this previously dull area is now resonant, you have produced evidence for the shifting dullness of ascites.
6. Confirm this by turning the patient over onto his left side, percussing now the right side *mutatis mutandis*. Of the classic tests for ascites, this testis one of the most sensitive (Tables 20.4 and 20.5). However, the mesenteric fat of the obese patient generates many false positives, thus lowering the specificity; Cope reported a false positive due to severe unilateral hydronephrosis (Silen, 1979).

Auscultatory Percussion

The "Puddle Sign"

A Method

1. Have the patient lie on his belly for 5 minutes and then raise himself up to a position on "all fours." That is, he is to support himself on his knees and forearms so that the middle portion of the abdomen is the most dependent. (The expectation is that any ascites in the peritoneum will now follow gravity to the most dependent portion and form a puddle there.)
2. Place the diaphragm of the stethoscope over the most dependent portion of the abdomen.
3. Perform auscultatory percussion by flicking one finger of the hand not holding the stethoscope at a constant light intensity at a constant location on the flank. Sound waves so generated are said to pass through any fluid that is present in order to reach the stethoscope. (This mechanism may not be correct; see the discussion of cage resonance in Chapter 16.)
4. Gradually move the stethoscope toward the *opposite* flank while continuing to percuss the flank you started on.
5. A positive sign consists of an abrupt perceived increase in the intensity and clarity of the note just as the stethoscope moves beyond the edge of the pool of fluid. If such a change is heard, repeat the procedure, flicking the opposite flank *mutatis mutandis*. Having found the border of the puddle on both sides, ask the patient to sit up. With the stethoscope in the same position as before, the percussion note from both sides should become clear, if the fluid is free flowing (and hence, in most cases of ascites), because the fluid will move inferiorly.

The interested reader is referred to the original work (Lawson and Weissbein, 1959), which includes phonocardiographic studies and dog experiments concerned with the exact acoustical components perceived by the ear. The originators were able to detect as little as 120 mL of ascites (Lawson and Weissbein, 1959), but this has not been a universal clinical experience (Cattau et al., 1982; McLean, 1987; Simel et al., 1988; Williams and Simel, 1992).

An Alternate Method. Simply place the stethoscope at the most dependent portion of the abdomen and flick with your finger, gradually moving it down the abdomen toward the stethoscope. It does not make much sound until it passes the ascitic fluid–intestine interface. Then with both the flicking finger and the stethoscope "under the puddle," the sound abruptly becomes noticeably louder.

An additional benefit of this method (which has not been standardized) is that sometimes, with small amounts of ascites, one can flick hard enough to "splash" some of the fluid. This squishing sound, heard through the stethoscope, might be called an *abdominoscopic succussion splash*.

Unfortunately, the position required for this test is very uncomfortable for both patient and examiner. For that reason alone, Guarino's variation might be preferred.

Guarino's Variation

A Method

1. Have the patient void, then have him sit or preferably stand for 3 minutes to allow free fluid to gravitate to the pelvis.
2. Hold the lower edge of the diaphragm piece of the stethoscope with one hand immediately above the pubic crest in the midline (Fig. 20-12).
3. Apply finger-flicking percussion with the other hand along three or more lines from the subcostal margin perpendicularly down toward the pelvis.

Interpretation. Normally, there is a sharp change from a dull note to a loud one along a horizontal line across the pelvic baseline (at the upper edge of the diaphragm piece, which has a diameter of 4.5 cm), owing to compression of the abdominal viscera. A change in note occurring above the pelvic baseline is strongly suggestive of intraperitoneal fluid. The demarcation disappears when the patient lies down and the fluid gravitates back into the flanks and reappears after 3 minutes in the upright posture (Guarino, 1986). In a study of patients undergoing ambulatory peritoneal dialysis, 140 mL of fluid could be detected with good agreement between observers. A clearer end point was obtained with a handheld ultrasound instrument than with a conventional stethoscope (McLean, 1987).

In a direct comparison between the puddle sign and Guarino's method of auscultatory percussion in 66 patients, using ultrasonography as the reference standard, auscultatory percussion was found to be more sensitive (66% vs. 45%) though less specific (48% vs. 68%). The puddle sign also requires the patient to be more

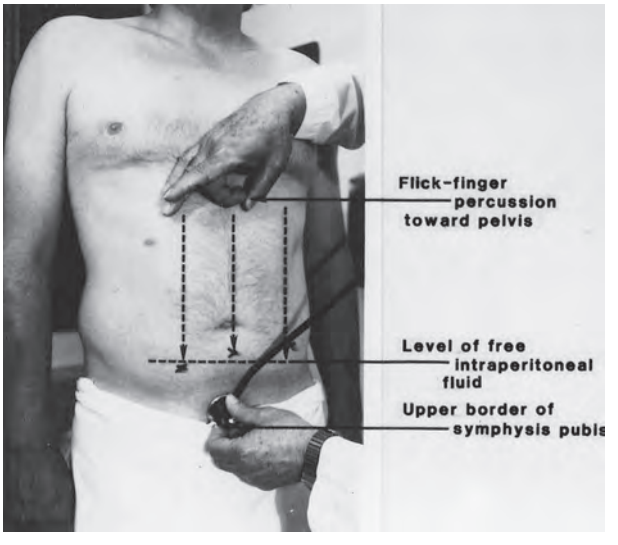

Figure 20-12 Auscultatory percussion with the patient erect may turn out to be more sensitive than with the patient prone. (Courtesy of Dr J.R. Guarino of Idaho.)

cooperative and is difficult to do in obese patients (Chongtham et al., 1997a).

Blaxland's Method. The differentiation of ascites from a massive ovarian cyst is given in Chapter 22. Fortunately, it is rarely needed as most ovarian cysts do not become large enough to produce dullness in the flanks.

Associated Findings

Certain items in the medical history (increased girth, recent weight gain, and ankle swelling) were even more predictive of the presence or absence of ascites than some of the tests described above (Tables 20.4 and 20.5).

Examination of the Liver

Inspection

Infrequently, a cirrhotic or cancerous liver may be observed during inspiration. Formerly, it was most often seen during inspection for the Litten sign (descent of the diaphragm observed in the axillary intercostal interspaces; see Chapter 16).

Palpation

Hanger, a clinician who invented one of the first liver function tests (the cephalin flocculation test), used to say that as far as the liver was concerned one good feel was worth two good laboratory tests.

A Method

1. With the patient supine and the physician at the patient's right, the examining hand is placed on the abdomen and moved downward and cephalad as the patient is instructed to take a deep breath. The deep inspiration flattens the diaphragm and moves the liver down against the examiner's exploring hand. Some examiners (pokers) place the hand on the abdominal wall, parallel to the rectus muscle with fingers pointing toward the patient's head, and poke for the edge of the liver. However, Dr Iber of Illinois is of the opinion that most contemporary hepatologists are hookers rather than pokers. By this, he means that they palpate the liver with the fingers (pointing at the patient's feet) hooked gently into the abdomen. In this way, the more sensitive finger pads (rather than the finger tips) are facing the edge of the liver. A position that is *not* optimal is placing the fingers parallel to the ribs instead of the rectus muscle so that you are not feeling with all your fingers.
2. Some examiners use the left hand to push adipose and other redundant tissue out of the way of the palpating right hand.
3. There are two technical problems related to the abdominal musculature. First, some persons have difficulty relaxing their abdominal muscles even with their knees and hips flexed. This is especially true when a strange, threatening person (the physician) is pushing on them. A better examination can be obtained in such subjects by the judicious administration of vocal anesthesia. For example, at the first sign of resistance, say slowly and softly, "Just take it easy … breathe comfortably … just pretend that my hand is going to fall down through your abdomen … all the way through your abdomen and your back … my hand is going all the way through your body to the bed, down to the floor." (Students have pointed out to me that when I do this, my voice assumes a dull, monotonous tone, and it sounds as though I am trying to induce a hypnotic trance.)

   A second problem, which causes a false positive, is that in some cases the anterior abdominal muscles overlap as they insert into the inferior rib cage. One is occasionally fooled into thinking one is feeling the liver when one is really feeling well-developed muscles. Because such healthy persons tend to develop their muscles symmetrically, just palpate under the left costal margin. If another "liver," of the same size, shape, and consistency as on the right, is felt there, you have not yet palpated the true liver.
4. There are two technical reasons for missing the liver during palpation: (a) severe abdominal distention, as with ascites, so that the exploring hand can never get down to the liver and (b) failure to begin the search far enough caudad, in a patient with massive hepatomegaly. If one begins cephalad to the liver edge, one might work all the way up to the right costal margin and never "catch the edge." This last is remediable! One way is to start looking in the right lower quadrant; ask the patient to breathe slowly and gently, and move your fingers up about 2 cm with each exhalation (Naylor, 1994).

The purposes of palpation are

1. To evaluate consistency
2. To feel the liver for nodules
3. To find extremely large, clearly abnormal livers
4. To detect systolic pulsations

Findings and Interpretation

1. A stony hard liver is caused by a tumor, a very hard liver with a sharp hard edge is usually cirrhotic, and a moderately firm liver may be due to acute passive congestion, which causes tension in Glisson capsule. Soft "normal" livers may be felt in fatty infiltration of the liver but are usually not massively enlarged.
2. When nodules are found by palpation, they usually signify cancer rather than nodular cirrhosis. Dr Iber believes that he can discriminate nodular livers. Tumors are said to be reliably differentiated from cirrhosis in that the former are "mountains on a plateau," whereas cirrhosis feels like "rivers on a plain."
3. It is to be emphasized that the liver is *not* palpated for the purposes of determining its exact size. Size is evaluated by percussion, the scratch test, or auscultatory percussion (see later in this chapter).

   A palpable liver is not necessarily enlarged. Using palpability as a sign of enlargement has a 54% false-positive rate if liver size is judged by the hepatic scintiscan (Rosenfield et al., 1974). This fact seems to be rediscovered every few years (Ariel and Briceno, 1976; Meyhoff et al., 1979; Naftalis and Leevy, 1963; Peternel et al., 1966; Riemenschneider and Whalen, 1965; Zoli et al., 1995) but is forgotten even more often (Halpern et al., 1974).

   Aside from the variability in palpatory measurements (Meyhoff et al., 1979), the length of a line cannot be determined just by knowing where it ends with respect to the right costal margin; one must also know where it begins. Yet our most

influential and popular medical journals publish clinical pathologic conferences with liver measurements in "finger-breadths below the costal border" units, a meaningless measure, even if all examiners had uniform finger-breadths and took care to take the measurement at the same phase of respiration.

In measuring the craniocaudal dimension of the liver in the right midclavicular line, many workers use a combination of percussion of the upper border and palpation of the lower border. Unfortunately, the lower border is often not palpable. Additionally, there are no scientifically verified normal values for this procedure. Finally, with this technique the mean maximum variation between four clinicians was 8 cm (Blendis et al., 1970).

When I have simultaneously determined a liver size by percussion-to-palpation and again by percussion-to-percussion (*vide infra*), the value obtained from the former is always greater than that obtained from the latter. The reason is that it is possible to get a hollow percussion sound over the inferior, thin edge of the liver and so underestimate its true size. This fact also explains why different techniques of liver percussion yield different normal values (*vide infra*).

4. *Expansive systolic hepatic pulsations*. These can be a sign of tricuspid insufficiency, aortic insufficiency, or constrictive pericarditis (see Chapter 17). It is less well appreciated that most *true* hepatic expansile pulsations (as distinct from the false positives due to misinterpretation of aortic pulse transmission) are not of either of these etiologies but are presystolic hepatic venous pulsations. The last generally have the same diagnostic significance as large A waves in the jugular venous pulse (see Chapter 19). (See Chapter 17 for the method of distinguishing expansile hepatic pulsations from hepatic bouncing caused by transmitted aortic pulsations.)
5. The three most common causes of pathologic liver enlargement are congestive heart failure, cirrhosis, and metastatic disease (S.H. Danovitch, *personal communication*, 2004).

Percussion

Some examiners recommend fist percussion over the liver to elicit the tenderness of hepatitis. The remainder of this section is only concerned with determining hepatic size.

A Method

1. Have the supine patient breathe quietly.
2. Percuss in the right midclavicular line, going from resonance to dullness. Use a (hard) percussion note. (The tone should be easily audible to the examiner when he is standing upright.)
3. Determine the upper and lower borders of dullness and measure the span between them.

Normal values for hepatic dullness are available from a nomogram (Castell et al., 1969), although this method severely underestimates the true size of the liver as determined by ultrasound (Homeida et al., 1976; Sapira and Williamson, 1979) or scintiscanning (Sullivan et al., 1976). This is because it is difficult to locate the dome of the liver by percussion (clinicians generally place it 2 to 5 cm too low) and because it is possible to obtain a resonant percussion note over a very thin lower edge of the liver (which is placed more than 2 cm too high in nearly 50% of all subjects [McGee, 1995]).

In the benchmark study (Castell et al., 1969), liver dullness was determined in 116 normal subjects. No independent covariable (e.g., ultrasound) was used. The mean liver dullness in the right midclavicular line for men (in centimeters) was found to be 0.032 times the weight (in pounds), plus 0.18 times the height (in inches), minus 7.86. For women, the mean liver dullness in the right midclavicular line was given by 0.027 times the weight (in pounds), plus 0.22 times the height (in inches), minus 10.75. The 95% confidence limits were ± 3 cm. A slide rule based on these calculations was developed by the Upjohn Company under the trade name Hepat-A-Rule. Such predictions are of limited value. The "normal span" has been variously estimated from 6 to 13 cm, showing the importance of individual variables, including the examiner's technique. It has been suggested that the "normal span" is unique to the examiner and not generalizable (McGee, 1995).

Note that the liver span on ultrasonography correlates only with the height, whereas the span by percussion correlates with both height and weight, suggesting that the patient's subcutaneous fat influences cage resonance and dampens vibrations, resulting in a larger span (McGee, 1995).

Williamson's Method

1. Have the patient hold his breath in deep inspiration during percussion. (This flattens the diaphragmatic dome, thus decreasing the error of underestimation.)
2. Percuss in the right midclavicular line to determine upper and lower borders of hepatic dullness. Use an *extremely* soft percussion note (i.e., one that can be heard only if the examiner places his ear close to the patient).

This method gives measurements closer to those from ultrasound (Sapira and Williamson, 1979) and a formula for converting to the true (ultrasound) value: $U = (G - 4.44)/0.603$, where U is the ultrasonically determined craniocaudal dimension of the liver in the right midclavicular line (in centimeters) and G (for gentle) is the same dimension (in centimeters) by Williamson's technique. However, because there are currently no normal values for adult liver size by ultrasound (no "gold standard"), the neophyte is advised to try both techniques: the former for the purpose of comparing the value with normal "dullness" and the latter against that future date when normal values for liver size become available.

Any given technique of percussion will yield intraobserver and interobserver variations of a little more than 2 cm (Castell et al., 1969; Malchow-Moller et al., 1984). Thus, each examiner probably needs to record his method, his own data, and his impressions (normal, large, or indeterminate).

Auscultation

The etiologies of murmurs over the right upper quadrant are discussed in Chapter 18.

Special Maneuvers

Auscultatory percussion and the "scratch test" (see Chapter 17) have also been used to estimate hepatic size as well as contour. The examiner places his stethoscope just beneath the xiphoid and

percusses or scratches, moving from the lower abdomen toward the costal margin, noting the point at which the percussion blow or scratch sound becomes greatly increased (Kukowka, 1972). Obviously, the percussion blows or scratches must be of constant intensity.

Many persons have difficulty with the scratch test because they scratch too vigorously and thus tighten the skin, producing false positives. One should scratch lightly and in a direction parallel to that of the expected liver edge. If the skin is already tightly stretched, as in severe ascites, one may obtain a false positive. The scratch test has been the subject of only one comparative study, in which it was found to be as good as (or as bad as) the techniques of palpation and (nonauscultatory) percussion for finding the lower edge of the liver, when compared with the results of a liver scintiscan. By almost any technique, the midclavicular dimension could be obtained in 50% of the subjects within 3 cm of that obtained by scintiscan (Sullivan et al., 1976). Given that the accuracy of the hepatic scintiscan in that study is also unknown, I am not sure that the examiners were as imprecise as they thought themselves to be. (Three observers gave unanimous opinions about the normality or abnormality of liver size in only 50% to 55% of scintiscans [Meyhoff et al., 1979].) In a study that included 11 examiners with varying degrees of training from nurse practitioner, medical student, to gastroenterologist, the scratch test was found to be both inaccurate and imprecise. The gold standard was the ultrasound examination, which was stated to be preferable to the scintiscan because the former determines anatomic rather than physiologic boundaries (Tucker et al., 1997). It is possible that the results have more to do with the physical examination skills of the usual rounding team than the test.

Of course, both the scratch test and auscultatory percussion should be used only when the lower boundary of the liver extends beneath the right costal margin. (In the study referenced above, 4 of 22 livers did not extend below the costal margin, as was determined by ultrasound.) Thus, these methods are not useful with small livers (or with advanced liver disease accompanied by ascites).

A different technique of auscultatory percussion was used by Gilbert: placing the stethoscope below the apex of the liver and tapping from midabdomen toward the liver with a Queens square hammer (a narrow, round-wheel hammer with a flexible thin handle). He stated that this method detected one case of hydrops of the gallbladder and one hydronephrotic kidney. In the latter instance, the patient had a palpable 5-cm subcostal mass. When the stethoscope was placed over the liver, the percussion sounds were not heard until the hammer reached the costal margin, whereas they were heard over the mass if the stethoscope was placed behind the right flank, suggesting that the mass was separate from the liver (Gilbert, 1994).

The Jaundiced Patient

The critical issue in managing the jaundiced patient is the possible need for surgery (Danovitch, 1987). A delay in treatment for "surgical" jaundice causes unnecessary suffering and, in some cases, risks death from cholangitis. On the other hand, surgery in a patient with acute hepatitis or decompensated cirrhosis carries a mortality of 10% to 25%. The paramount question is the patency of the bile duct.

The most important discriminator is age. Surgery is seldom needed in patients under the age of 30. In patients over the age of 60, about half the cases of jaundice are the consequence of extrahepatic biliary obstruction.

In the presence of pain and pruritis, a surgical diagnosis is three times as likely as a medical one. An influenzalike illness preceding the jaundice occurs three times as often in patients with "medical" jaundice. Alcohol consumption exceeding 80 g per day or exposure to a hepatotoxin indicates a nonsurgical cause as do physical findings of chronic liver disease (ascites, spider angiomata, and splenomegaly). An enlarged spleen occurs in only 5% of patients with obstructive jaundice (Danovitch, 1987).

If surgical jaundice is suspected, obtain an urgent consultation. In 2004, magnetic resonance cholangiopancreatography was probably the imaging method of choice, or one might go directly to endoscopic retrograde cholangiopancreatography if stenting or stone extraction was needed (S.H. Danovitch, *personal communication*, 2004).

Examination of the Spleen

Inspection

Inspect the abdomen during inspiration, and see whether a left upper quadrant mass descends. (If it does, it *might* be the spleen.)

Palpation

The spleen, in contrast to other masses in the left upper quadrant, moves greatly with inspiration and *may* have a readily palpable notch (the splenic hilus).

Several Methods

1. With the patient supine, stand at the patient's right, and feel for the spleen with your right hand below the costal margin, pressing your fingers in deeply. (The examining fingertips will be felt to ride momentarily over the edge of the spleen at the zenith of inspiration.)

   In cases of extreme splenomegaly, you may not catch the lower edge of the spleen, the palpating hand being above it. Thus, a general sensation of resistance in this position requires moving the palpating hand down into the lower left quadrant and slowly inching up so as to catch the lower edge of such elephantine spleens.

   a. The above method may be improved upon by placing the left hand in the subcostovertebral area and, simultaneously with the right hand's palpation, pulling upwards with the left hand so as to provide a better definition of the spleen.
   b. In very obese patients, it may be necessary to place the left hand more anteriorly so that it can press away intervening adiposity. However, in patients who are very obese, this trick seldom finds a spleen that is not apparent to percussion (*vide infra*).
   c. Bailey (Clain, 1973) suggests placing the left hand over the lateral aspect of the costal margin and drawing the skin and subcutaneous tissues downward toward the right hand. This leaves a loose fold of skin under the costal margin.

d. To avoid pushing the spleen away, some suggest placing only the index finger lightly just below the left costal margin (Lipp et al., 1944).

2. Ask the supine patient to place his left fist under the left costovertebral angle. Stand to the patient's left, facing his feet. Curl the fingers of both hands under the left costal margin and ask the patient to take a long, deep breath. This is called the *hooking maneuver of Middleton* (Grover et al., 1993).
3. Place the patient in a *modified* right lateral decubitus position, modified in that the flexed right arm supports the dependent right rib cage, throwing the left subcostal area into aerial relief. Stand behind the patient and palpate with the right hand anterior to the left hand, the latter being at the posterior axillary line. The pulp of the fingers "hooks" over the costal margin and down to the spleen edge.
4. Have the patient sit in a chair while you lean over the patient's left shoulder from behind. Palpate with your left hand in the patient's left anterior axillary line and your right hand medial to the left, covering the subcostal area from the left midclavicular line laterally. Both hands feel for the spleen.
5. Place the patient in the prone position, supporting himself on his knees and elbows or his knees and chest. Standing at his left, use your hand to try to catch a spleen tip.

   Using the fourth or the fifth method, I have not yet been able to palpate a spleen that was not apparent from examination by the first or the third method.

   In all positions, the patient should be instructed to breathe *deeply* so that the left hemidiaphragm will move the spleen down into the palpating range. Because many patients respond by tensing the abdominal muscles, give the instruction to breathe deeply *after* you have positioned your hands.

   If you are not sure whether you have felt a spleen tip, ask the patient to report his sensations. He will often describe a "catching" sensation if indeed your hand or fingers have touched his spleen.
6. Place a pillow beneath the knees of the supine patient. Have the patient push the spleen forward by placing his left fist beneath his ribs. Stand on the left side of the patient's head and search with the fingers of both hands under the left costal margin (Clain, 1973).
7. A Russian method involves rotating the patient into the right lateral decubitus position and palpating with the right hand, with the examiner remaining on the right side of the bed (Povzhitov and Mironets, 1978). A detailed description is also available in English (Mitchell, 1973). With the patient in the same position, using the left hand for palpation makes this a Danish method (Videbaek et al., 1982).
8. A unique Danish method involves rotating the patient into the left lateral decubitus position (Videbaek et al., 1982).
9. It has been claimed that splenic palpation may be facilitated by having the patient jump up and down 20 to 25 times before palpation, which is carried out by having the patient stand in front of the examiner and bend slightly forward (Bremen, 1973).
10. Bimanual palpation, the right hand reinforcing the costovertebral space and the left hand feeling below the left costal margin, may be employed with the patient standing (Lipp et al., 1944).

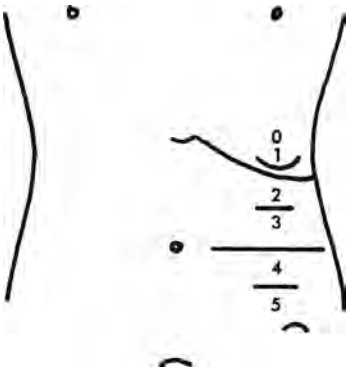

FIGURE 20-13 Hackett's semiquantitative system for measuring spleen size. 0, normal or nonpalpated spleen ("negative" spleen); 1, spleen palpable only when the subject draws a deep breath; 2, spleens ranging from those at the costal margin palpable without assistance from the subject to those whose lower border reaches a point halfway to a horizontal line through the umbilicus; 3, spleens projecting more than halfway to the umbilical level but not beyond it; 4, spleens below the umbilical level but not more than halfway to the line of the symphysis pubis; 5, all spleens larger than those mentioned above.

Quantitating Spleen Size

A semiquantitative system for measuring spleen size (Hackett, 1944) is given in Fig. 20-13.

False Positives

1. *Pseudosplenomegaly*, in my experience, most commonly turns out to be colonic feces. In general, a very large mass will turn out to be spleen, not feces. (The splenic notch has not proved to be helpful in making the distinction because it is not usually identifiable with absolute certainty.) The gold standard for distinguishing the two is reexamination after purgation or an enema.

   Renal cysts and tumors, the left lobe of the liver, and lower costal cartilages have also been misidentified as the spleen.
2. Many palpable spleens are neither pathologic nor enlarged (Dell and Klinefelter, 1946). Palpable but not pathologic spleens have been found in 2.3% to 3.8% of patients in an office practice (Lipp et al., 1944); 3% of presumably normal college freshmen who were "none the worse for it on incomplete follow-up" (McIntyre and Ebaugh, 1967); 10.4% of hospitalized patients who were having liver scans (Sullivan and Williams, 1976); and 12% of women in the immediate postpartum period who had extreme relaxation of their abdominal musculature (Berris, 1966).

Sensitivity

The reported sensitivities for palpation of splenomegaly range from 28% (Halpern et al., 1974) to 100% (Aito, 1974).

Actually, the sensitivity increases with increasing size of the spleen, as determined by scintiscan, being 50% for moderately enlarged spleens (600 to 750 g), 80% for greatly enlarged spleens (900 to 1,600 g), and approaching 100% with the largest spleens (>2,350 g) (Fischer, 1971; Fischer and Wolf, 1973).

Interrater Reliability

All four observers agreed on the presence or absence of splenomegaly by palpation in 88% of 32 patients (Blendis et al., 1970).

Hardness

Once you have palpated the spleen, it is important to attempt to determine whether it is hard like a Genoa or Kosher salami or merely tense like an uncooked wiener. If hard ("firm"), the splenomegaly is fibrotic and thus chronic, as in 44% of patients with Laënnec's cirrhosis (Ratnoff and Patek, 1942). If merely tense, the splenomegaly is acute.

Percussion

A Method

Percuss over the lowest intercostal space in the left anterior axillary line during expiration and deep inspiration (Castell, 1967; Castell and Frank, 1977). Enlarged but nonpalpable spleens will cause a dullness of the percussion note during deep inspiration, with resonance returning during expiration when the diaphragm and spleen again move cephalad.

This technique is best learned upon a patient whose palpable splenomegaly is resolving. Daily examinations will determine a point at which the percussion sign is still positive although the examiner can no longer definitely feel the spleen tip. Resolving splenomegaly of this type is most commonly found in infectious mononucleosis, viral hepatitis, and in about 10% of patients with thyrotoxicosis who have just been definitively treated.

Another Method

In a resurrection of a 19th-century technique, splenomegaly has been evaluated by percussing the spleen outline with the patient in the right lateral decubitus position (Nixon, 1954). Normal values were not determined.

Traube's Space

Percussion of the semilunar space of Traube (see Fig. 16-9), originally described for the detection of subpulmonic effusion or other pathology in the left lower chest, has been investigated as a sign of splenic enlargement. The percussion note was classified as definitely tympanitic, probably tympanitic, uncertain, probably dull, or definitely dull. The best receiver operating characteristic curve was obtained by defining tests with definitely or probably tympanitic percussion notes as negative and all others as positive. The gold standard was ultrasound. Excluding obese patients and those who had eaten within 2 hours of the examination, a sensitivity of 78% and a specificity of 82% were obtainable (Barkun et al., 1989).

Comparing Various Methods

In a study that directly compared Nixon's percussion method and Castell's percussion method on the same 48 normal and 17 enlarged spleens, using the spleen scintiscan as the independent covariable, Castell's technique was found to be more sensitive (82%) than palpation in two positions (70%) but also had a higher false-positive rate (17%). Conversely, Nixon's method was found to be less sensitive (59%) than palpation but had a lower false-positive rate (6%) (Sullivan and Williams, 1976). When using scintiscans as an independent covariable, remember their high rate of false positives when compared with the plain radiographic length of the spleen (Westin et al., 1972), a point often documented but rarely acknowledged (Aito, 1974). Although the scintiscan is considered to be an "objective" test, sanctified as revealed truth by virtue of being typed on a laboratory slip, in fact, the interpretation is also quite subjective, especially in the absence of scientifically determined normal values for spleen size (Sapira, 1981).

TABLE **20.6** *Diagnosticity of various bedside maneuvers to detect splenomegaly in nonobese, fasting patients (%)*

Maneuver	Sensitivity	Specificity	PPV	NPV
Supine palpation	79	92	92	80
Middleton's maneuver	86	87	88	85
Traube's space percussion	76	63	70	71
Castell's maneuver	67	82	80	69

PPV, predictive value of a positive test; NPV, predictive value of a negative test.
From Chongtham DS, Singh MM, Kalantri SP, et al. Accuracy of palpation and percussion manoeuvres in the diagnosis of splenomegaly. *Indian J Med Sci.* 1997b;51:409–416, with permission.

A study of five methods, in the hands of one examiner, using ultrasound as the gold standard, investigated 42 patients with splenomegaly and 38 normals. All patients had been fasting for at least 2 hours and none were obese (Chongtham et al., 1997b). Results are shown in Table 20.6. In contrast to an earlier review (Barkun et al., 1989), which concluded that palpation was unnecessary unless the percussion note was dull, this study showed that palpation was significantly better than percussion. This author concludes that more information is better than less and that learners should avoid taking shortcuts.

Differential Diagnosis of Splenomegaly

While many books of differential diagnosis list dozens of entities under splenomegaly, it is possible to shorten the lists drastically by using combinations of findings or modifiers of findings. (The power of combinations of nonspecific findings is explained in Chapter 27.) The specific lists were suggested by those in *Major's Physical Diagnosis* (Delp and Manning, 1975) and thus are based upon the experiences of Dameshek, Welsch, Major, Delp, Manning, and Wilson. Two reminders are needed. First, all diagnostic medicine is playing the odds; thus, in any given case, there is a small chance that through omission a listing (iterative) method may not initially include the correct diagnosis. Second, it is most efficient to place the lists in order of increasing length and hence decreasing utility, as in Table 20.7.

Self-study

Combinations of lists may be used. Prove to yourself the power of lists and combinations by noting the diagnostic possibilities for a patient with hepatomegaly, massive splenomegaly, and a normal hematocrit. Write them down now before referring to Appendix 20.3.

TABLE **20.7** *Differential diagnosis of splenomegaly*

A. Splenomegaly in the presence of intense jaundice (i.e., total bilirubin > 10 mg/dL)
   1. Hepatic disease with portal hypertension
B. Splenomegaly and less-than-intense jaundice
   1. Hepatic disease with portal hypertension
   2. Hemolytic anemia
C. Splenomegaly and pallor
   1. Leukemia
   2. Lymphoma
   3. Hypersplenism of any cause
D. Splenomegaly and significant lymph node enlargement
   1. Lymphocytic leukemia
   2. Lymphoma
   3. Sarcoidosis
E. Splenomegaly and hepatomegaly
   1. Hepatic disease with portal hypertension
   2. Leukemia
   3. Polycythemia vera
   4. Hemolytic anemia
   5. Myeloid metaplasia
   6. Gaucher disease
F. Massive splenomegaly (i.e., a spleen that is clearly below the umbilicus even during expiration, a "4" or "5" on the spleen-o-meter in Fig. 20-13)
   1. Chronic granulocytic leukemia
   2. Myeloid metaplasia
   3. Polycythemia vera
   4. Hodgkin disease
   5. Malaria
   6. Kala azar
   7. Gaucher disease
G. Smaller spleens than in F
   1. Infections
   2. Pernicious anemia
   3. Hemolytic anemia
   4. Sarcoidosis
   5. Acute leukemia
   6. Hepatic disease with portal hypertension
   7. Chronic lymphocytic leukemia
   8. Other lymphomas
   9. Any of the entities in list F, during the time the spleen is enlarging to its maximum

Auscultation

Bruits and rubs over the spleen were discussed earlier in this chapter.

Splenic Rupture

Splenic rupture usually has a history of abdominal trauma, which may be followed by a deceptive period relatively freed from symptoms. At presentation, there may be tenderness in the left upper quadrant, abdominal rigidity (in about half the cases), and even shock.

Special maneuvers helpful in the diagnosis include shifting dullness and referred pain or hyperesthesia in the shoulder (usually, but not invariably, the left, called the *Kehr sign*). The last is *not* made worse by movement of the joint or pressure over the site but rather by having the patient lie supine for about 10 minutes with the foot of the bed raised 0.5 m. If the peritoneal cavity contains liquid blood, this maneuver will cause it to gravitate toward the diaphragm, bringing on the symptoms and signs of diaphragmatic irritation (Clain, 1973).

Gallbladder

The Murphy Sign

A Method

A modification of Moynihan's method of eliciting the Murphy sign of acute cholecystitis is as follows.

1. With the patient supine, place your left hand, with your fingers pointing toward the midline, on the patient's lowermost right anterior rib cage so that your index finger is reposing on the most inferior rib. Although the exact location of the gallbladder is more variable than suggested by most textbooks, some part of your thumb will now be resting over an area to which the patient's gallbladder can be brought by deep inspiration ("X" marks the spot in Fig. 20-7).
2. Abduct your extended left thumb, rotate it in opposition down and into the patient's belly and hold it there.
3. Instruct the patient to take a deep breath.
4. Keep your thumb where it is. Do not lean on the patient's rib cage. If you are doing the test correctly, you should feel the rib cage move up toward you during the inspiration.
5. When the inflamed gallbladder is driven down to a point at or near the indentation produced by your thumb, the patient will experience pain or tenderness sufficient to cause an abrupt halt in inspiration. This often occurs only toward the end of inspiration.
6. Repeat with a placebo maneuver. Put your hand in the same position, but do not push in with your thumb. If the patient can now complete a full inspiration, whereas he could not do so before, the Murphy sign is positive for acute cholecystitis.

One study found that the Murphy sign has a sensitivity of only 27%; the study dealt with patients with chronic cholecystitis and cholelithiasis (Gunn and Keddie, 1972). Dr Peter Hallas of Copenhagen points out that studies of patients with acute cholecystitis found better results for this sign. The sensitivity and specificity were, respectively, 62% and 96% (Eskelinen et al., 1993), 97% and 48% (Singer et al., 1996), 44% and 62% (Popescu et al., 1992), and 48% and 79% (Adedeji and McAdam, 1996). The positive LR is 2.0 and the negative LR nonsignificant (McGee, 2001). Age is likely to be a significant factor in explaining the differences. The symptoms and signs of an acute abdomen in older patients are not as classic or specific. The mean age of the patients was 38 in the Eskelinen study and 79 in the Adedeji study.

Other

Signs of an acutely inflamed gallbladder are the Boas sign and the gallbladder rub.

The Courvoisier Law

The Courvoisier "law" states that an enlarged gallbladder in the presence of (obstructive) jaundice signifies cancer rather than cholecystitis with cholelithiasis. The underlying thesis is that the chronically scarred gallbladder cannot expand but that the one acutely obstructed by neoplasia can. But in fact, the gallbladder *was* enlarged in 20% of cases of jaundice due to cholelithiasis. In the same series, the gallbladder was *not* enlarged in 8% of cases of jaundice due to a cause other than a stone (e.g., cancer) (Courvoisier, 1890).

Caveats

1. The law is applicable only for jaundiced patients.
2. The law is based upon a pathologic experience in 19th-century Europe. We have no information about the operation of the law for a 21st-century clinician trying to palpate, in vivo, the gallbladder of an obese American.
3. Because neither the normal-sized gallbladder nor the enlarged gallbladder perfectly predicted the presence or absence of either stones or cancer, it is doubtful that the Courvoisier law is actually a law, except in the sense that a speed limit is a law.

On the Clinical Diagnosis of Gallbladder Disease

There is no single finding with sufficient diagnosticity to establish or exclude acute cholecystitis without further testing, such as a right upper quadrant ultrasound. Studies to assess various findings suffer from both verification bias and spectrum bias. The paucity of patients with atypical findings in study samples overestimates the sensitivity and underestimates the specificity of findings. Diagnosis relies on clinical "gestalt" and the use of imaging (Trowbridge et al., 2003). Characteristics of pain are discussed in Chapter 3.

The fact that the patient has presented in the emergency department has a remarkably high specificity for gallbladder disease in contradistinction to hiatal hernia, peptic disease, and other upper abdominal conditions (S.H. Danovitch, *personal communication*, 2004).

The Kidneys

> *Falstaff: Sirrah, you giant, what says the doctor to my water?*
> *Page: He said, sir, the water itself was good healthy water; but for the party that owned it, he might have more diseases than he knew of.*[2]
>
> Shakespeare, King Henry IV, Part II, Act I, Scene II

Inspection

In modern times, the kidneys are inspected by means of imaging technology. Intravenous pyelography or ultrasound is being replaced with "helical" or "spiral" computed tomography.

Curiously, the sectional area of both kidneys as measured planimetrically in square centimeters is about the same as the individual's height in inches (Black, 1962).

As a rule, the kidneys will not differ in size by more than 1.5 cm. Irrespective of the adult patient's body size, a kidney less than 10 cm in length is suspicious, as is one greater than 15 cm.

[2] Examination of the urine was a well-established practice in Elizabethan times.

Much can be learned about the kidneys by inspection of the urine (see Chapter 28).

Palpation

In thin subjects, it is possible to palpate one and often both kidneys bimanually.

A Method

Attempt to palpate the right kidney in the following manner:

1. With the patient supine, stand comfortably at the patient's right and put your examining hand (the left hand) behind the patient's right loin. Put your right hand in the right upper quadrant or below the lower edge of the liver (which you have already located) and gently push your right hand down and your left hand up.
2. Before you begin to push and as you move your hands toward each other, say to the patient in a gentle, calm voice, "I want you to pretend that my hand is going to fall down through your belly, all the way through the back of your body, all the way through the bed, down to the floor," all the while increasing the pressure.
3. In the case of a palpable kidney, you are most likely to feel the rounded edge by moving your right hand down and medially. If you can palpate the kidney but are not hitting the lower edge, work your fingers interiorly and medially to be sure that you are not feeling a horseshoe kidney.
4. Then work your right hand as high up as you can and try to get some estimate of the size and texture of the kidney.
5. Repeat for the left kidney, *mutatis mutandis*.

Variations on the Theme

Some workers palpate for the kidney with one hand, putting four fingers under the flank and pressing the thumb down from above. Others use the bimanual approach but have the patient assume the lateral decubitus position, always examining the superior side.

Findings

As with other findings that have come down to us from the 19th-century masters, kidney palpation was perfected in underfed middle-European clinic patients. Except for a few ectomorphs, such persons are less frequently encountered these days. Inability to feel the kidneys through several centimeters of adipose tissue is of little use in the negative sense. (In fact, if you can feel the kidneys of an overweight person, it might suggest an abnormality, the strength of the suggestion being in direct proportion to the patient's adiposity.) To emphasize the fact that normal subjects (especially if large and skinny) may have palpable kidneys, consider a recent study of members of a family that had some members with polycystic kidney diseases, wherein the examiners found at least one palpable kidney in 14% of those family members subsequently shown *not* to have polycystic kidneys (Gabow et al., 1984).

Bilaterally palpable, enlarged kidneys should suggest the possibility that the patient has polycystic kidney disease or bilateral hydronephrosis.

If *one* kidney is palpably enlarged, think of hydronephrosis if it is tender and firm. If it is stony hard, the diagnosis is carcinoma until proven otherwise.

But we can rarely be certain that a hard mass in the right or left upper quadrant is carcinoma of the kidney. A hard mass on the right is more likely to be a colonic carcinoma than a kidney carcinoma. And the more caudally that one feels the hard mass, the more likely it is to be colonic rather than renal.

On the left, one is more likely to be feeling carcinoma of the kidney than carcinoma of the colon. Pancreatic carcinoma comes in a distant third followed by the spleen, the *bête noire* of the novice. (See earlier in this chapter to review distinguishing features of the palpable spleen.) These discriminatory features are mentioned here in an archival sense as I expect them to be lost in the coming decades owing to the technique of abdominal ultrasound, the Golem[3] of modern medicine.

The horseshoe kidney is the only type that will be palpable crossing the midline.

Percussion

A Method

Simply punch over the right and left kidneys (with equal force) with the ulnar surface of your fist. One wishes to strike hard enough to jar diseased bone or viscera but not so hard as to produce pain in normal structures. For this purpose, start the blow no more than 6 in. (15 cm) from the back.

Significance

Acute pyelonephritis, perinephritis, and renal abscess may manifest as punch tenderness over the kidney. These tend to be unilateral as do the false positives from the rare retrocecal appendix (on the right) or an inflamed Meckel diverticulum. False positives due to musculoskeletal disease are usually bilateral.

"Intrinsic renal disease," such as chronic interstitial fibrosis, arteriolar nephrosclerosis, and Kimmelstiel–Wilson disease, does not cause tenderness either to punch or thumb pressure (*vide infra*), despite statements to the contrary.

The Thumb Pressure Test

Sometimes, the thumb pressure test may be helpful in making the distinction between tenderness from kidney disease and that from musculoskeletal disease. Applying pressure very slowly, push your thumbs as firmly as you can over the same costovertebral areas that elicited punch tenderness. If this procedure does *not* cause tenderness, it is presumed that the patient is more likely to have pyelonephritis than musculoskeletal disease of the back. However, a positive test (tenderness) is of no help.

Auscultation

Auscultation of the renal arteries is discussed in Chapter 18.

[3] The Golem was a homunculus created out of inanimate matter by magic, as in the Frankenstein legend. Abdominal ultrasound reminds me of the Golem of Prague in that it is quite useful provided that it comes down from the attic only when its master calls for it. It is like the Golem of Chelm in that it can create terrible confusion when it is permitted to run amok among the thoughtless. Remember, Frankenstein was the name of the doctor.

The Bladder

The urinary bladder may be palpable in thin persons if greatly distended or if fibrosed as a sequela of radiation therapy. Otherwise, bladder distention must be diagnosed by auscultatory percussion (Guarino, 1981) as follows.

With the patient supine, place the diaphragm (Guarino, 1985) of the stethoscope above the symphysis pubis in the midline and hold it there with one hand (Fig. 20-14A). With the pulp of one finger of the other hand, percuss along the vertical midline, beginning above the umbilicus and proceeding caudad one finger width at a time until there is a sharp change, that is, an increased volume of the percussion note. This is the upper edge of the bladder, as can be verified with phonoscopy (Fig. 20-14B).

The distance above the symphysis pubis at which the percussion note changed was shown to predict accurately the likelihood that the patient had a full bladder, defined as at least 250 mL of urine on subsequent catheterization (Table 20.8).

If you think you have detected a large bladder by this technique, try percussing the lateral borders in a similar manner. The distended, enlarged bladder assumes an ellipsoid outline in the frontal percussed representation.

The great Czech physician and professor of medicine in Vienna, Joseph Skoda, could diagnose a bladder stone by auscultating at the symphysis pubis and listening to the friction of a catheter rubbing against the bladder stone (Sakula, 1981).

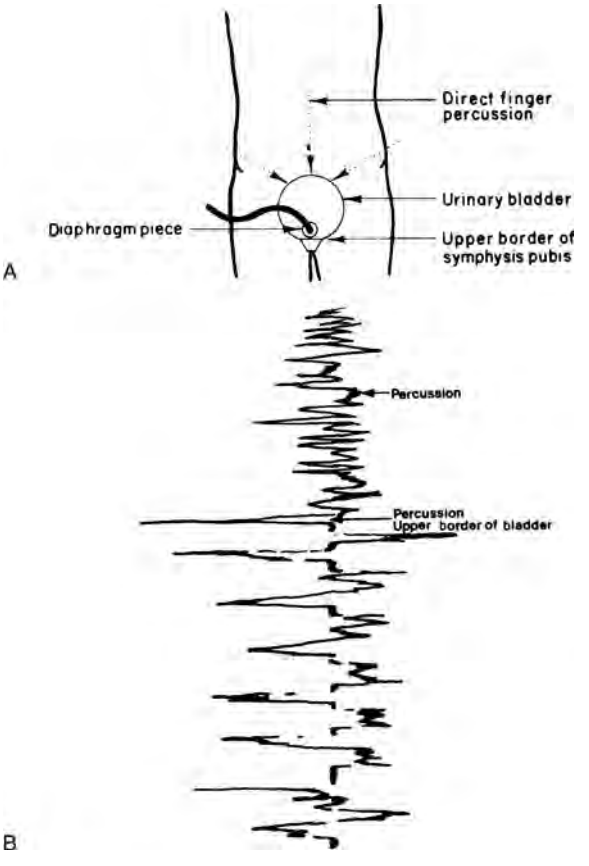

Figure 20-14 **A:** Auscultatory percussion of the bladder. **B:** Phonoscopy tracing of a 33-year-old woman with a distended urinary bladder. A sharp, loud change in note with auscultatory percussion defines the upper border of the bladder.

TABLE **20.8** *Auscultatory percussion for determining bladder distention*

Distance above pubis at which percussion note changes (cm)	Likelihood of a full bladder (%)
0–6.5[a]	0
6.5–7.5	43
7.5–9.5	91
>9.5	100

[a]Measurements to the right of the decimal point not to be taken too seriously.
From Guarino JR. Auscultatory percussion of the urinary bladder. *Arch Intern Med.* 1985;145:1823–1825, with permission.

The Pancreas

The pancreas is an organ that, in its normal condition, cannot be inspected, palpated, percussed, or auscultated. The diagnostic perfidiousness of the pancreas was remembered by medical students of my time when they were asked in anatomy class: "How is the pancreas like a faithless woman?" (Because all day long it lies in the arms of the duodenum, but at night, it gives its tail to the spleen.)

Nevertheless, in a diseased state, the pancreas can produce physical findings.

Inspection

A pancreatic pseudocyst or a hemorrhagic pancreatitis may produce visible signs (see earlier in this chapter).

Palpation

Between 45% and 65% of pancreatic pseudocysts are palpable (Shatney and Lillehei, 1979), and a diminishing abdominal mass might be a spontaneously draining pseudocyst. Patients with acute or chronic pancreatitis may have the Mallet–Guy sign. Have the patient assume the right lateral decubitus, knee-chest position and press deeply in the area where splenomegaly might be (but is not) present. The presence of tenderness, not otherwise elicited, is a positive sign. The explanation is that the overlying organs fall to the right in this position, exposing the body and the tail of the pancreas to direct pressure (Clain, 1973).

Auscultation

Pancreatitis often causes secondary ileus manifesting as absent bowel sounds. A murmur due to compression of the splenic artery occurs in 37% of cases of pancreatic carcinoma (Bauerlein and de la Vega, 1963).

Appendix 20.1

Differential Diagnosis of the Patient in Fig. 20-5

In the patient shown in Fig. 20-5, pregnancy is doubtful because of the apparent age. Ovarian cyst would not explain the tissue in the patient's hand. She might be coughing because of metastatic disease or tuberculous disease, which might also involve the liver and/or peritoneum. Therefore, I favor the diagnosis of ascites.

Appendix 20.2

Which Side Has the Perinephric Abscess?

If the patient in Fig. 20-7 actually had a perinephric abscess, it would be on the right because the patient is bent over toward that side. The pain could be aggravated by having the patient bend back toward the left.

Appendix 20.3

Answer to Self-study on Differential Diagnosis

The diagnostic possibilities for the triad of hepatomegaly, massive splenomegaly, and a normal hematocrit are myeloid metaplasia, chronic granulocytic leukemia, and Gaucher disease.

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CHAPTER

21

Male Genitalia

… The husband had long been suffering from ulcers in the private parts, and his wife insisted on seeing them, promising that no one would give him a more candid opinion whether the disease was curable. She saw that there was no hope and urged him to take his life; she went with him, even led him to his death herself, and forced him to follow her example by roping herself to him and jumping into the lake.

—*The Letters of the Younger Pliny*, Book 6

Points to Remember:

- Many dermatologic conditions characteristically affect the penis or scrotum. Be sure to inspect the urethral meatus and the area beneath the foreskin of an uncircumcised male.
- Be aware that syphilis has been transmitted by a single treponeme, and that syphilis is still the great imitator.
- Surgical emergencies involving the scrotum and its contents include gangrene, testicular torsion, and strangulated hernia. Nearly a fourth of men who first consult a primary physician for testicular torsion lose a testicle owing to delayed diagnosis.

Embarrassment and anxiety on the part of both patient and physician can cause harmful or even fatal delays in the recognition and treatment of diseases in the genital region. Physicians do a great disservice to patients by neglecting this aspect of the physical examination. As with the female genital exam, the physician must take care to respect the modesty of the patient.

Penis

A Method

1. Put on a pair of gloves, remembering that some organisms such as *Treponema pallidum* can be infective through the skin[1] (Harrison et al., 1978).
2. Inspect the penis, looking for any ulcerative or exophytic lesions. Remember to retract the foreskin, if present, or have the patient do so. (Be sure to return the foreskin to its usual state; unconscious patients have developed severe edema after the examiner failed to do this.) Do not retract the foreskin if it is painful or too tight (see phimosis, discussed later in this chapter).
3. In order to inspect for ulcers, warts, and discharge, open the terminal urethra by compressing the glans anteroposteriorly between your thumb and forefinger. Note the location of the urethral meatus, normally at the tip of the glans penis.
4. To detect masses, induration, or tenderness, palpate the length of the shaft, including the lateral corpora cavernosa as well as the length of urethra.

Ulcers

The distinguishing features of ulcers of various etiologies are given in Table 21-1 (Figs. 21-1–21-3). Additionally, fixed drug eruptions can affect the genitalia, causing intensely painful bullous lesions that may become necrotic. Some patients so afflicted have been mislabeled as having herpes simplex. As always, a complete drug history is warranted (Goldman, 2000).

The mucous membrane of the urethra may be involved in systemic diseases that cause mucosal ulcerations, such as Behçet disease, pemphigus, and Stevens–Johnson syndrome.

Other Skin Lesions

Nonulcerating dermatologic diseases that characteristically involve the penis include psoriasis, scabies, and lichen planus.

Psoriasis is the most common inflammatory condition affecting the male genitalia. The patient may have no history of psoriasis or lesions elsewhere and the well-defined erythematous plaques lack the characteristic psoriatic scale (Goldman, 2000).

Contact dermatitis may result from topical agents applied to other areas and transferred to the genitalia from the hands. Obtain a complete history of the use of such preparations. Poison ivy and other forms of Rhus dermatitis are also transferred in this way.

In secondary lues, a papulosquamous eruption typically involves the penis, palms (Fig. 21-4), and soles. This skin lesion is teeming with spirochetes and is highly infectious.

Reiter syndrome is frequently accompanied by circinate balanitis, a painless eruption on the glans. These begin as small blebs that coalesce into a large circular ring about the size of a dime.

Condylomata lata (See Fig. 22-5) are flat growths about the genitalia or anus seen during the secondary stage of syphilis. Condylomata acuminata (venereal warts), which occur in the same locations (See Fig. 22-4), have villous projections, and as these are caused by a virus, they are infectious.

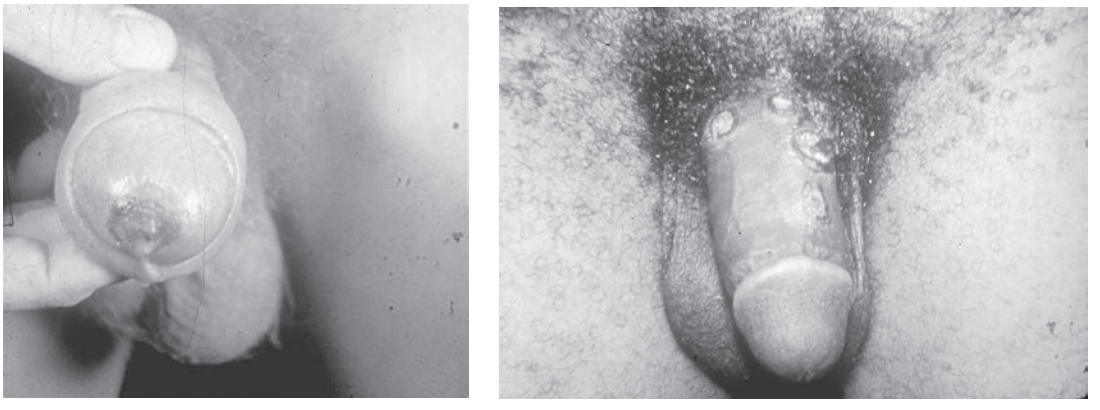
Herpes simplex can initially appear as small grouped vesicles on an erythematous base, which then open and resolve as ulcers. These are highly infectious.

Malignant melanomas occur on the male genitalia, most commonly on the glans or urethra, but are very rare, much rarer than on the vulva (Ahmed, 1997).

[1] The minimal infective dose of *T. pallidum* in rabbits has been determined to be one treponeme injected intratesticularly and four organisms inoculated intradermally (Public Health Service, 1968).

TABLE **21.1** *Ulcers of the penis*

Etiology	Usual number	Pain?	Lymphadenopathy?
Syphilis	One (but multiple chancres not rare)	No (unless superinfected)	Usually bilateral
Chancroid	Multiple	Tender	Bilateral but usually more pronounced on one side
Granuloma inguinale	One (more likely to be inguinal)	No	No
Lymphogranuloma venereum	One (tiny, vesicular)	Not usually but the lymphadenopathy is painful	Usually unilateral
Herpes simplex	Multiple (vesicular at first), occur in clusters	Yes	No
Cancer	Single	Not initially	Eventually



A B

FIGURE 21-1 Primary syphilis. **A:** Meatal chancre. **B:** Primary chancres of the penile shaft, showing that these can be multiple. The lesions are usually firm and indurated with a crusted or ulcerated surface and a raised border. The size varies from a few millimeters to 1 or 2 cm. (Courtesy of Division of Sexually Transmitted Diseases, Center for Prevention Services, Centers for Disease Control, Atlanta, GA.)

FIGURE 21-2 Chancroidal ulcers. Lesions are generally multiple, soft, ulcerated with a grayish base, and quite tender. Dark-field examination is negative: *Haemophilus ducreyi* may be demonstrated from the lesion by direct smear or culture. (Courtesy of Division of Sexually Transmitted Diseases, Center for Prevention Services, Centers for Disease Control, Atlanta, GA.)

FIGURE 21-3 Granuloma inguinale, with both active and healed areas. (Courtesy of Division of Sexually Transmitted Diseases, Center for Prevention Services, Centers for Disease Control, Atlanta, GA.)

FIGURE 21-4 The papulosquamous eruption of secondary syphilis. (Courtesy of Division of Sexually Transmitted Diseases, Center for Prevention Services, Centers for Disease Control, Atlanta, GA.)

Cancer of the penis can be either nodular or ulcerating. While it is rare, morbidity and mortality are relatively high because of delays in diagnosis occasioned by embarrassment, denial, or lack of awareness.

Foreskin

Record whether the patient is circumcised. If not, be sure to retract the foreskin completely and inspect the complete coronal sulcus and glans.

In the event that urine cultures for mycobacteria are done to look for extrapulmonary dissemination of tuberculosis, be aware that laboratories unable to distinguish species could mistake *Mycobacterium smegmatis*, a contaminant present in the smegma of uncircumcised men, for *Mycobacterium tuberculosis*.

Penile cancer hardly ever occurs in circumcised men. (Cancer of the cervix is also less common in the wives of circumcised men.)

Phimosis

Phimosis is the inability to retract the foreskin because of a congenital malformation, adhesions from infection, or scarring from traumatic retraction of the foreskin during childhood or adulthood.

Paraphimosis

Paraphimosis is the inability to replace the foreskin because of phimotic cicatrix that squeezes down on the penis behind the coronal sulcus. This causes severe pain and edema of the glans because of obstruction of lymphatic and venous return. It can easily be misdiagnosed as glanular edema if the examiner does not realize that the patient is not circumcised. The foreskin needs to be replaced immediately; this usually requires urologic consultation.

Peyronie Disease

Peyronie disease is also known as *plastic induration of the penis*. The patient may complain of curvature of the penis during erection, toward the side of the plaque. Feel for plaques, which are occasionally tender, in the corpora cavernosa laterally or in the intercorporeal septum dorsally. The condition is more common in men who have used penile self-injections to treat impotence.

Priapism

Priapism is a prolonged, usually painful erection of the corpora cavernosa, initially unaccompanied by sexual desire. The glans penis is usually not engorged. It may signify a neurologic lesion from the cerebrum to the nervi erigentes; a local mechanical cause, such as thrombosis, hemorrhage, neoplasm, or inflammation of the penis; or a thrombotic diathesis due to a hematologic condition such as leukemia or sickle cell anemia (hemoglobin S-S), or even sickle trait (hemoglobin S-A). (Hemoglobin S undergoes sickling when the partial pressure of oxygen in the blood decreases [PO_2]. Persons with hemoglobin S-A usually have PO_2 levels sufficient to prevent sickling—except when they travel by air.) Additional causes of priapism include Fabry disease, amyloidosis, malaria, black widow spider bite, and recent infection with *Mycoplasma pneumoniae*.

Priapism can also be seen following self-injection of vasoactive agents, as well as use of some oral agents. Up to 21% of cases of priapism are associated with alcohol abuse or drug therapy (Thomas et al., 2003). Take a careful drug history, including the use of illegal agents. Drugs associated with this condition include many psychotropic medications (including chlorpromazine, clozapine, bupropion, trazodone, fluoxetine, sertraline, lithium, mesoridazine, perphenazine, and hydroxyzine), hydralazine, metoclopramide, prazosin, tamoxifen, testosterone, calcium-channel blockers, anticoagulants, cocaine, marijuana, and 3,4-methylenedioxymethamphetamine (MDMA or "ecstasy"). Priapism has also been reported with infusion of a 20% fat emulsion in the course of total parenteral nutrition.

Most men have delayed presentation for many hours because of embarrassment. Delay increases the likelihood of complications such as impotence. Priapism is an emergency requiring immediate treatment.

Congenital Malformations

In hypospadias, the urethra opens on the ventral surface of the penis, from just inside the meatus all the way down the shaft to the penoscrotal junction. This may occur as an isolated anomaly (in 1 of 700 newborn boys). In about 15% of cases, there is some pathogenetic mechanism identified, such as in Klinefelter syndrome (karyotype XXY), other chromosomal abnormalities, maternal ingestion of estrogens or progestogens, or virilizing congenital adrenal hyperplasia in a genetic female (Williams, 1974). Hypospadias may accompany nondescent of the testicle. An asymmetric "hooded" foreskin is often seen with hypospadias.

In epispadias, the urethra opens dorsally.

Urethral Discharge and Urethritis

A thick, purulent-appearing discharge is likely to be a sign of gonorrhea. A slight, whitish discharge is more likely to be due to one of the causes of "nonspecific" (nongonococcal) urethritis

such as *Chlamydia, Ureaplasma*, or even a presumably noninfectious condition such as Reiter syndrome. Place a drop of the discharge on a slide, allow it to air dry, and prepare a Gram stain to look for leukocytes and gonococci (see Chapter 28).

Sexually transmitted diseases (STDs) may be present even in the absence of symptoms and may only come to the patient's attention because of a diagnosis made in a partner (see Chapter 22). Men attending an STD clinic were found to have a 17% prevalence of *Trichomonas*, 19.6% of chlamydia, and 17.7% of gonorrhea. In men with nongonococcal urethritis, 19% were infected with *Trichomonas* (Schwebke and Hook, 2003).

Impotence (Erectile Dysfunction)

The physical examination of the penis is seldom helpful in evaluating one of the major causes of morbidity in men, sexual impotence (erectile dysfunction [ED]), unless it is a result of an end-organ problem such as Peyronie disease, phimosis, microphallus, or chordee (Nelson, 1987).

One special maneuver, the postage-stamp test (see Chapter 3), is useful for distinguishing impotence of a central (psychogenic) origin from that secondary to a problem in the neurovascular axis (endocrine, vascular, peripheral neuropathy, etc.). Vascular impotence may be evaluated by measuring the penile–brachial blood pressure gradient (see Chapter 18) but requires Doppler equipment to make the penile artery pressure determination.

See Chapter 3 for a discussion of the history and differential diagnosis in ED.

Scrotum

Observation of the scrotum is best performed with the patient in a standing position. Many lesions and abnormalities of the scrotum are easily seen. Look for masses, erythema, skin lesions, hydrocele, condyloma, or loss of rugae. Palpate the scrotum gently between the thumb and forefinger, feeling for masses or skin lesions, dilated veins (see varicocele), thickening, or other irregularities.

The scrotum and scrotal contents should be examined in a consistent, routine fashion, starting with the scrotum itself, then the testicles, the epididymis, the spermatic cord, and the external ring.

Be alert to causes of an acute scrotum, which may constitute a surgical emergency. These are listed in Table 21-2 and discussed with the appropriate anatomic site.

Skin Infections

In secondary syphilis, papulosquamous (Fig. 21-5) or annular squamous lesions may occur on the scrotum, as well as the penis and thighs.

Progressive ulcerative or fistular lesions of lymphogranuloma venereum may affect the penis, urethra, or scrotum. Mycoses commonly afflict the skin of the groin; *Tinea cruris* usually does not involve the scrotum, whereas *Candida albicans* frequently does. The diagnosis of *Candida* is also suggested by scattered satellite lesions beyond the main area of dermatitis (Harrison et al., 1978); these are primarily seen in the skin folds and groin area.

TABLE **21.2** *Causes of an acute scrotum*

Testicular torsion
Epididymitis
Torsion of testicular appendage
Orchitis
Inguinal hernia
Idiopathic scrotal edema
Henoch–Schönlein purpura
Tumor
Trauma
Extrascrotal pathology

From O'Brien WM, Lynch JH. The acute scrotum. *Am Fam Physician.* 1988;37:239–247, with permission.

The papules and vesicles of scabies, often accompanied by eczematoid lesions, have a predilection for the scrotum, as well as the belt line, umbilicus, buttocks, axillae, and upper thighs.

The Fordyce Lesion

The Fordyce lesion (Fig. 21-6) consists of multiple, minute (petechia-sized), dark nodules, hyperkeratotic over a vascular core, slightly raised, with a discrete border. They exactly resemble caviar lesions of the tongue (black caviar, not red) with which they may

FIGURE **21-5** Secondary syphilis. Papulosquamous lesions of penis, scrotum, and thigh. Lesions may have a psoriasiform appearance. (Courtesy of Division of Sexually Transmitted Diseases, Center for Prevention Services, Centers for Disease Control, Atlanta, GA.)

FIGURE 21-6 Fordyce lesions.

coexist. They may be confused with the lesion of Fabry disease (angiokeratoma corporis diffusum universale); however, the latter, as indicated in Latin, are not confined to the scrotum. More recently, they have been confused with the early lesions of Kaposi sarcoma (see Fig. 7-15), but the Fordyce lesions are much smaller.

Fordyce lesions are seen in 15% of men over the age of 50 (Bean, 1958). They may be transmitted from father to son but do not generally appear until after age 40 (although the patient shown in Fig. 21-6 was 39 years old).

The lesion is benign and a biopsy need not be performed. However, it may bleed and thereby be associated with psychic morbidity. Accordingly, the patient should be reassured and advised to maintain a high order of hygiene to prevent itching and the need for abrasive scratching.

Other Skin Lesions

Small hemangiomas are common as are small sebaceous cysts. These can break open, ooze a white, pasty substance, and then heal, only to reappear later on. True abscesses may be noted and are associated with tenderness and erythema. These should be drained immediately.

The angiokeratomata of Fabry disease (painful crises of which may mimic renal colic) are clusters of red, nonblanching angiectases on the trunk, perineum, penis, and scrotum.

The recurrent ulcers of Behçet disease involve the scrotum and the mouth.

Henoch–Schönlein purpura can be the cause of an acute scrotum in young boys, generally associated with other signs of this systemic disease, such as a purpuric rash.

Gangrene of the Scrotum

In the universe of anaerobic and mixed (synergistic) gangrene (cellulitis and/or fasciitis), "Fournier" (1883) refers to that of the scrotum, regardless of organism. "Meleney" refers to gangrene, regardless of locus, attributed to the *Peptostreptococcus* and *Staphylococcus* but indistinguishable at the perineum from cutaneous amebiasis (Davson et al., 1988). Fournier gangrene is almost always associated with an underlying urologic or colorectal problem, including postsurgical states. Rarely, it may be related to small-vessel disease such as that of diabetes mellitus or polyarteritis nodosa (Downing and Black, 1985). Often, more than one of these factors is present (Lamb and Juler, 1983; Spirnak et al., 1984).

Rapidly progressive scrotal swelling and erythema, with patches of black, necrotic skin, require immediate surgical exploration and drainage, as well as antibiotics. Scrotal gangrene is associated with high mortality, which can be reduced with hyperbaric oxygenation. The gangrene can spread along tissue planes up into the chest or down into the legs.

Varicocele

Often described as a "bag of worms," a varicocele is a dilated cluster of veins within the scrotum, located just above the testicle. Up to 15% of adult men have a palpable varicocele, which is usually asymptomatic, although occasionally men will complain of a heavy, achy feeling in the scrotum, especially after running or walking. Nearly 50% of infertile men have a varicocele (Jarow et al., 1996), and varicoceles are the most common cause of poor sperm production and decreased semen quality.

To increase the likelihood of detecting a varicocele, examine patients while they are standing and have them perform a Valsalva maneuver. You may be able to feel a thrill over the varicocele.

Most varicoceles (between 80% and 98%) occur on the left. However, when men in an infertility clinic were examined with contact thermography, Doppler sonography, and venography of both testes, varicoceles were found to be bilateral in 80% (Gat et al., 2004).

Aside from its importance in an infertility workup, these are the clinical circumstances in which the finding of a varicocele is cause for concern:

1. An isolated right varicocele, or the acute appearance of any varicocele, should raise concerns over an intra-abdominal process that raises the intravenous pressure, such as a renal cell carcinoma or renal vein thrombosis.
2. In a patient with nephrotic syndrome, the *appearance of any varicocele* justifies a search for renal vein thrombosis.
3. A pulsating varicocele is seen in tricuspid insufficiency (Fred, 1988).
4. If a varicocele develops during adolescence, the growing testicle on that side is often smaller than the contralateral one. This ipsilateral growth arrest is caused by increased temperature due to the increased volume of blood adjacent to the testicle. A varicocele identified during and after puberty may affect future fertility, and surgical correction may be indicated. Following ligation of the internal spermatic vein on that side, rapid growth of the testicle occurs (S. Marks, *personal communication*, 1998).

Edema

Edema of the scrotal wall can occur in any condition causing massive fluid retention (see Chapter 24) and is often seen in men who are bedridden or suffering from congestive heart failure. Local causes include thrombosis of the pelvic veins, acute epididymitis, and torsion of the spermatic cord (DeGowin, 1965).

Lymphedema results from obstruction of the pelvic lymphatics. In filariasis or a small percentage of cases of lymphogranuloma venereum, the condition may be so severe that it is called *elephantiasis*.

Idiopathic scrotal edema may occur in prepubertal boys; the testes should be palpably normal.

Transillumination of Scrotal Swelling

Scrotal masses are often fluid collections within the spermatic cord, adjacent to or surrounding the testicle or part of the testicle or epididymis. To help define these lesions and separate them from more serious solid masses, one can easily transilluminate the scrotum.

A Method

1. Pull the blinds or take the patient to a darkened room.
2. Make the swelling tense by grasping the neck of the scrotum between the fingers and thumb.
3. Place a strong light behind the scrotum.

Findings

A hydrocele or epididymal cyst should be translucent, and the opaque shadow of the testis may be visible. A hematocele, tumor, or hernia will not allow light to pass through. Any questions about an intrascrotal or testicular abnormality should be evaluated further with testicular ultrasound.

Referred Pain

Pain in the scrotum may rarely be the presenting sign of problems elsewhere, such as an intervertebral disc herniation or ruptured intra-abdominal viscera with a secondary hematocele. The pain of nephrolithiasis with ureteral obstruction is often referred to the scrotum.

Testes, Epididymis, and Spermatic Cords

Testis is the Latin word for testicle. The words "testament" and "testify" are derived from the same root. (In the ancient world, there was no Bible to swear upon and witnesses were required to take the oath of the court while holding onto their gonads, the implication being that if they did not tell the truth something would fall off. This also explains why women were not called to court.)

Inspection

To note the position of the testes, one should examine the scrotum with the patient standing. One side often hangs lower than the other, as shown in Fig. 21-7. This is not abnormal, but a change noted by the patient calls for evaluation. With testicular torsion, the testicle may be pulled high up into the scrotum. Sometimes testicular masses can be seen.

Palpation

A Method

1. The testicles are exquisitely sensitive and should be handled by the physical diagnostician with great care. Not only should they be palpated *gently*, but also physicians practicing in cool times or places should warm their hands by friction before beginning the examination. The most common cause of an undescended testicle has been said to be a physician with cold hands.
2. Feel the testis between your thumb and fingertips. Most important is to distinguish the testis from the epididymis. These are clearly two separate structures. The testis has the consistency of a hard-boiled egg or a rubber ball and lies vertically in the dependent portion of the scrotum. The epididymis is a soft, wormlike structure that lies lateral and posterior to the testicle, running from top to bottom. (This elementary distinction apparently escapes many physicians; an oncologist from Massachusetts once told me that he had never seen a patient with a seminoma who had not first received a course of antibiotics for the treatment of "epididymitis"!)

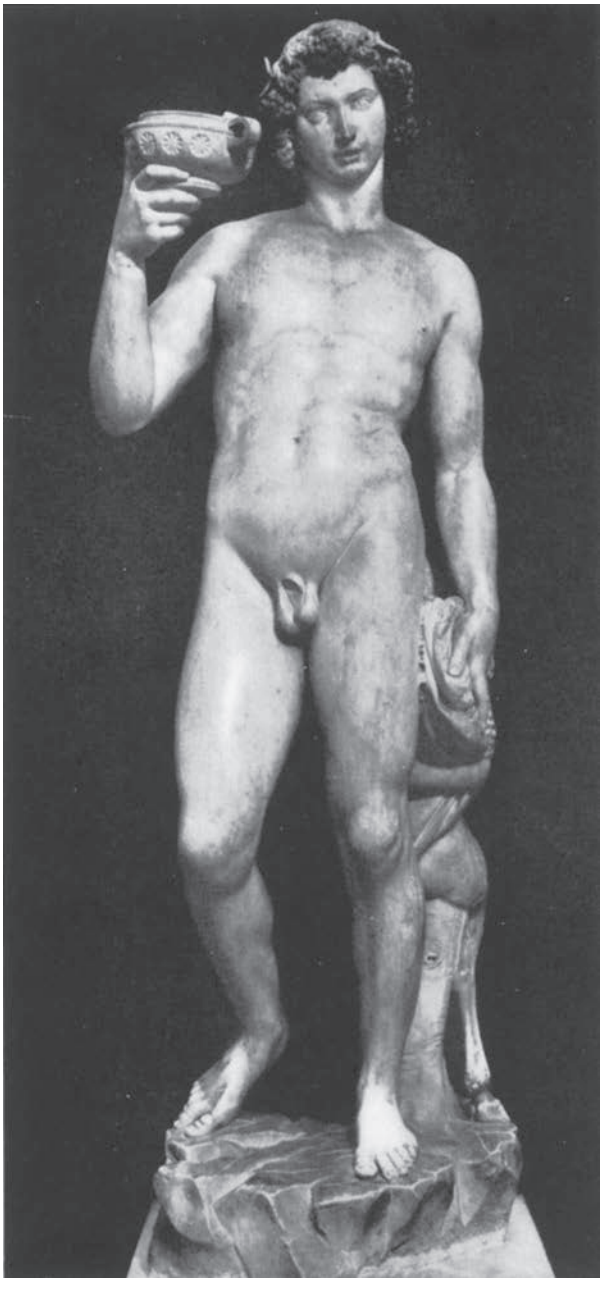


FIGURE 21-7 The right testicle hangs lower than the left. (Bacchus, by Michelangelo.)

3. While performing the examination, teach the technique to the patient (just as when examining the female breast).

   Cancer of the testis is the most common solid tumor in men between 20 and 34 years, and there is some evidence that testicular self-examination will permit the early detection of stage I tumors (Garnick et al., 1980). Unfortunately, it is still possible for testicular germ cell tumors to metastasize to clinically detectable extragonadal sites at a time when the primary testicular tumor is still detectable only by ultrasound, not by palpation (Kirschling et al., 1983).
4. When a swelling is found, you should be able to feel the *top* of the swelling within the scrotum if the swelling is of testicular origin. (If he is unable to do so, other possibilities such as a hernia should be considered.)

Findings

Testicular Size

The scientific literature on testicular size uses volumetric measurements and models that can be purchased. As a rule of thumb, I have noticed that the average testicle of androgenically normal men is always at least the same length as the distal two phalanges on the patient's little finger (except in patients with a marfanoid habitus). Using calipers, one can accurately measure the long axis of the testicle, for which normal values are available (Tishler, 1971). The lower limits of normal (mean minus two standard deviations)[2] are 31 mm for whites and 34 mm for blacks. The testicles of Japanese men are normally smaller than those of white men (Takihara et al., 1983). Whatever the size, it should be about the same bilaterally.

Bilaterally small testes occur in Klinefelter syndrome, myotonic dystrophy, and secondary hypogonadism. A small testicle (usually unilaterally but sometimes bilaterally) may result from atrophy after involvement with mumps, syphilis, trauma, filariasis, maldescent, or repair of an inguinal hernia.

Testicular Mass

A nontender swelling or mass in the testis may occur with neoplasm, tuberculosis, or tertiary syphilis (with the formation of a gumma).

A hard nodular mass in the testicle is usually neoplastic. Some tumors can be felt as a marble-sized mass within a testicle. Occasionally the tumor may replace all the normal tissue so that the testicle is the normal shape but is quite hard throughout as compared with the normal side. Testicular tumors are often nontender. As is so often the case with genital pathology, the patient may have been aware of the growth for some time (S. Marks, *personal communication*, 1988). However, malignant tumors can present as an acute scrotum (O'Brien and Lynch, 1988). Some patients with testicular tumors first seek medical treatment after an episode of trauma.

A swelling due to the accumulation of fluid or blood within the tunica vaginalis will feel smooth and resilient. It may be a hydrocele (which transilluminates, *vide supra*) or a hematocele (which does not).

[2] I abandon here the use of 95% confidence limits because the raw data were not corrected for body size, and the lower 95% confidence limits (41 mm for whites, 44 mm for blacks) would falsely diagnose many small, but androgenically normal, men.

Testicular Torsion

In testicular torsion, a twisting of the spermatic cord results in occlusion of the arterial supply and venous drainage. The condition is an acute emergency; failure to make the diagnosis may result in the loss of the testis because of compromised blood supply and consequent death of tissue. The patient usually reports the acute onset of unilateral testicular, groin, and abdominal pain. It can occur after exercise, when it is assumed to be traumatic, but can also occur during sleep. Unfortunately, as many as 35% to 50% of patients report a gradual onset, similar to that associated with epididymitis (O'Brien and Lynch, 1988). Torsion is most often seen in adolescents but can occur as late as the fifth decade. Up to one third of patients may have a previous history of similar pain that resolved spontaneously. The patient will be in severe distress and will have a tender, edematous mass in the scrotum. The differential diagnosis includes acute epididymo-orchitis and strangulated scrotal hernia. It is stated that the following signs favor testicular torsion (Clain, 1973).

1. The affected testis lies higher than its fellow.
2. It is believed that a developmental abnormality predisposes to torsion, in that the testicle lies horizontally rather than vertically. This is often referred to as the "bell clapper deformity." Quite often the unaffected testicle has the same orientation.
3. In testicular torsion, it is unusual to be able to distinguish the epididymis from the testis. If the epididymis can be felt in any position other than the normal posterolateral one, torsion is likely. A normal position, however, *does not exclude torsion* because the testis may have rotated 360 or 720 degrees (O'Brien and Lynch, 1988).
4. It is said that elevation and support of the testis for 1 hour will diminish the pain of epididymo-orchitis but not of torsion. *This is not true. Moreover, time is of the essence*. Delay is likely to cause loss of the testicle.

If torsion is suspected, immediate surgical exploration is warranted. An immediate testicular Doppler study may be used to evaluate blood flow but only if it will not delay diagnosis and treatment (S. Marks, *personal communication*, 1998). If blood flow is restored within 6 hours, 80% to 100% of testes can be saved. After more than 24 hours of continuous pain, salvage rates drop to 20%.

Some studies have shown that a patient with testicular torsion who consults a "primary-care" physician stands a 25% chance of losing a testicle because of treatment for epididymitis and a consequent delay in the correct diagnosis (Haynes et al., 1983).

Orchitis

Pain and swelling of the testis occur in orchitis, which may be caused by mumps, syphilis, gonorrhea, or other infections. In acute pyogenic orchitis, the scrotal skin is reddened and edematous, and there is often an associated hydrocele. Atrophy of the affected testicle follows mumps orchitis in about half the cases (O'Brien and Lynch, 1988).

In children, epididymo-orchitis is rare (no cases were found in patients younger than 18 years in a series of 129) and differentiation from torsion is difficult. Scrotal exploration has been

advised for every child presenting with localized pain and swelling: "The diagnosis of orchitis in a child is made at the operating table" (Leape, 1967).

Epididymal Lesions

Acute epididymitis is an exquisitely painful swelling and inflammation of the epididymis, which can be quite disabling. Usually unilateral, it can involve any part or all of the structure. The onset of pain may be gradual, and it is often accompanied by associated symptoms of infection such as fever and pyuria. In boys, bacterial epididymitis is usually associated with a congenital genitourinary tract abnormality, and in older men, it is associated with an acquired anatomic abnormality. In postpubertal men under the age of 35, underlying structural abnormalities are rare and the most common agents of infection are *Neisseria gonorrhoeae* or *Chlamydia trachomatis*.

Other forms of epididymitis are traumatic, obstructive (as after vasectomy), or chemical (from the irritation of sterile urine reflux from the prostatic urethra upon straining).

It is essential to distinguish epididymitis from torsion or tumor.

The most common abnormality of the epididymis is fullness following vasectomy. This is usually asymptomatic, although it can be tender. One should describe the area of fullness, such as the head, the body, or the tail of the epididymis. Sometimes a cyst, called a *spermatocele*, develops. This can be quite tender. Occasionally, one can palpate a nontender, soft or hard, little mass just off the head of the epididymis. This represents the appendix epididymis or appendix testis, a vestigial structure. The structure is often pedunculated and can rotate on itself, resulting in a miniature version of torsion, of just this appendix. The pain can be severe, and the condition can be confused with torsion of the testicle or epididymis. Occasionally, the examiner can see a small area of deep blue under the skin, the "blue dot sign." Conservative therapy usually works, if the correct diagnosis is made, but surgery may relieve the pain immediately (S. Marks, *personal communication*, 1998).

Cysts in the epididymis may occur in polycystic kidney disease.

Enlarged and/or cystic epididymides in the region of the caput are frequently seen in Young syndrome, which is associated with obstructive azoospermia (but motile sperm), chronic sinopulmonary infections, and a normal sweat test (Handelsman et al., 1984).

Tuberculosis and gonococcal infections may begin in the epididymis and secondarily spread to the testes. An examination of the epididymis is especially important in patients suspected of having disseminated tuberculosis.

Spermatic Cord

The spermatic cord contains the vas deferens, the cremasteric muscles, and the blood supply to the testis and epididymis. Abnormalities are rare, but it is important to palpate the cord from the inguinal canal down to the testicles bilaterally. Sometimes a cyst in the cord is noted. One should try to feel the vas, a thick, cordlike structure, and note whether there is any gap or sperm granuloma consistent with a previous vasectomy. Irregularities, nodules, or masses should be noted. Rarely, paratesticular tumors, primarily sarcomas, can be found in the cord. Unilateral absence of the vas is associated with absence of the ipsilateral kidney. Bilateral absence of the vas can be seen with cystic fibrosis.

Hernias

Ordinarily, a hernia is diagnosed by seeing or palpating a bulge. Occasionally, a large scrotal mass will turn out to be an inguinal hernia. In this case, it will not be possible to palpate above the mass. Rarely, one can hear bowel sounds.

Chronic, undiagnosed groin pain in male patients may be caused by an incipient hernia in up to 50% of cases. Gradually increasing pain, with worsening during periods of increased abdominal pressure, is suggestive. "Sports hernia," most frequent in soccer and hockey players, is also called "groin disruption" or "posterior abdominal strain." These patients typically do not have a palpable mass, and referral is needed for possible herniography or surgical exploration (Seidenberg and Childress, 2005).

A Method

1. The patient stands, stripped below the waist, while you sit in front of him.
2. Carefully look for a bulge. Keep your eyes glued on the external inguinal ring, and ask the patient to cough; observe whether there is an impulse or a bulge. Ask the patient to cough again, and compare the two sides.
3. If you do not see a swelling, but the patient has reported a pain or swelling, ask him to point to the spot where he felt it. Then look again as the patient coughs.
4. Using the right hand for the right side, and the left hand for the left side, invaginate the scrotum upon the index finger. Rotate the finger as you push it up along the cord so that the pad of the finger is facing the patient.
5. Palpate the superficial inguinal ring with the fingertip; the normal size ring will just admit the tip of the little finger. (A larger ring does not necessarily imply the presence of a hernia.)
6. Ask the patient to cough. Some hernias can be felt as bulges against the tip of the finger, while others can be felt as masses protruding through the abdominal wall along the cord.
7. If a hernia is felt, try to put it back inside, noting any difficulty, the size of the defect if palpable, and any tenderness. If it is difficult to reduce the hernia while the patient is standing, try again with the patient supine. Do not try to force it.

Zieman's Method

1. Follow steps 1 to 3 above.
2. Adjust the patient's position. Have him turn his head to the side and hold it erect, instead of looking down to see what you are doing.
3. With the patient still standing, you rise. For examining the right, stand behind and somewhat to the right, and for examining the left, stand behind and somewhat to the left. Using the hand corresponding to the side to be examined, spread the fingers as if catching a ball, and place the third finger over Hesselbach triangle (the site of a direct hernia). The second finger will then be over the site of an indirect hernia, and the fourth finger will be over the site of a femoral hernia. Instruct the patient to hold his nose and blow. Feel for the gliding motion of the walls of an

empty sac or the pushing sensation caused by the protrusion of a viscus into the sac (Clain, 1973).

Prostate and Seminal Vesicles

The prostate and seminal vesicles are palpated in the course of the digital rectal examination (see Chapter 23), which is an indispensable part of the examination of the male genitalia.

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CHAPTER 22

Female Genitalia

Members of generation are common to both sexes, or peculiar to one; which, because they are impertinent to my purpose, I do voluntarily omit.

—Robert Burton, *Anatomy of Melancholy*, Part 1, Section 1, Member 2, Subsection 4

Points to Remember:

- Always obtain a complete menstrual and obstetric history.
- The pelvic examination is pertinent in any woman with abdominal signs or symptoms, fever of unknown origin, or urinary symptoms.
- Take care to respect the patient's modesty and to make her comfortable, explaining what to expect. Having a chaperone present is essential if the examiner is a man, and often desirable even if the examiner is a woman.
- Inspect external genitalia, vaginal mucosa, and cervix, and take appropriate specimens for the laboratory. Besides screening for cervical cancer, frequent screening for *Chlamydia* in at-risk women is important because of the risk of infertility owing to asymptomatic infections.
- Palpate cervix, uterus, and adnexae for tenderness, consistency, mobility, size, and masses, and do not neglect the rectal and rectovaginal examination.

Overview

Importance of the Pelvic Examination in General Medicine

For many women, a pelvic examination is a traumatic event, sometimes because of past experience with insensitive examiners (Magee, 1975). Apparently, many physicians find it bothersome also, judging from the frequency with which the examination is "deferred" (i.e., not done). This omission can cause an important diagnosis to be missed (e.g., pregnancy). A surprising number of women in their first trimester have had major surgical procedures that would have been postponed had the surgeon known of the pregnancy, and many inappropriate medications have been prescribed. To avoid such errors, the date of the last menstrual period should be ascertained at each visit, even if the pelvic examination is done by the patient's gynecologist when indicated.

The pelvic examination is particularly crucial, even if not "due," in patients with abdominal signs or symptoms, fever of unknown origin, or urinary complaints. Many a pelvic abscess has remained undiagnosed for days, and many a case of vaginitis has been inappropriately treated as "cystitis." Although they are hidden, the female organs are seldom impertinent to the physician's medical purpose.

A Case History

An immensely obese, alcoholic patient was admitted late at night to the medical service of a well-known county hospital. The chief complaint was abdominal pain. The intern diagnosed pancreatitis, passed a nasogastric tube, ordered intravenous fluids, and went to bed.

The next morning, the nurse called frantically to inform him of the presence of a newborn infant in the patient's bed.

The Environment

Every effort should be made to protect the patient's privacy. When equipping a room for performing pelvic examinations, be sure that the table does not have its foot facing the door. The patient will be worried about someone opening the door and will not be able to relax. The room should be provided with a curtained-off area where the patient can undress and leave her clothing. This area should be supplied with tissues, individually packaged sanitary pads, and a wastebasket, for the patient's use after the examination. It goes without saying that the room should be kept warm, with an extra space heater if necessary.

Equipment

The physician will need the following for the routine pelvic examination.

1. A good light source. A light source in the speculum itself (Fig. 22-1) is best. A gooseneck lamp is usually the best available. A flashlight, with someone to hold it, is the bare minimum.
2. An examining table with stirrups, and a low stool with wheels. If it is absolutely necessary to examine a hospitalized patient in bed, an upside-down bedpan may be used to elevate her hips. This should give adequate elevation for performing the speculum examination (*vide infra*).
   Remember that the stirrups are always both cold and hard. Oven mittens of the type with the thumb in the middle (Fig. 22-2) make adequate coverings if you do not have the sheepskin kind. Alternatively, the patient may wish to leave her shoes on.
3. *Three* disposable gloves. You may want to begin with two gloves on the hand that will eventually be used for the rectovaginal examination.
4. Lubricant, such as KY jelly. Previously, physicians were instructed not to lubricate the speculum so as not to interfere with interpretation of the cytologic smear. Many gynecologists now say that water-soluble lubricants can be used.
5. A cytobrush, wooden scraper, or whatever collection devices are preferred by the histopathologist in the laboratory that

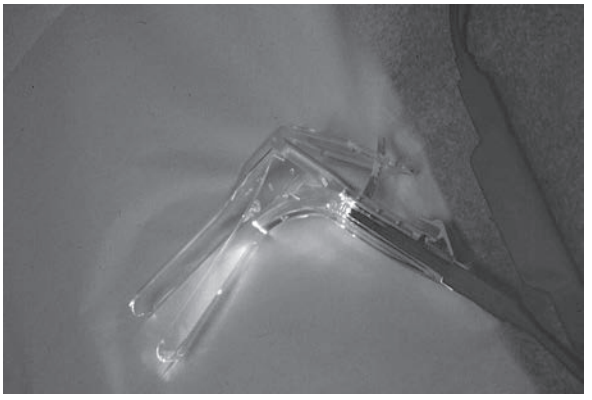

Figure 22-1 A plastic speculum with attachable light source. (Courtesy of Dr Devra Marcus, Washington, DC.)

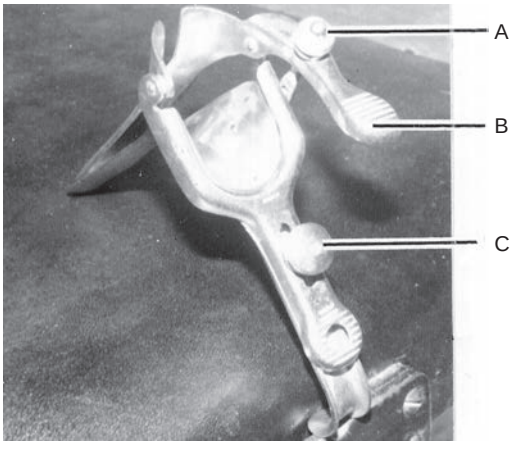

Figure 22-3 Graves speculum. **A:** Lateral set screw. **B:** Thumbpiece. **C:** Central set screw.

will do the Papanicolaou (Pap) smear. The Wallach Papette or broom-collection device, or the Pap Perfect Plastic Spatula, may be needed if the lab is using the newer, more expensive ThinPrep Pap test (Papillo et al., 1998). Read the instructions supplied by the laboratory carefully. Some techniques permit viral typing as well as cytologic examination.

6. Slides and fixative as needed by the laboratory for the Pap smear. (Long ago, one pathology laboratory simply pasted a different label on a can of commercial hair spray.)
7. Several other slides and coverslips for examining cervical mucous and/or vaginal discharge, if you have a microscope and are permitted to use it.
8. Transport medium that the laboratory provides for gonococcal cultures. Many labs supply a solution for a DNA probe.
9. Supplies for other tests if indicated (polymerase chain reaction [PCR] for herpes, viral cultures, slides for *Chlamydia*, and so on, obtained from the laboratory that is to perform the tests). The viral medium may need to be kept frozen and thawed just before it is inoculated. Be sure to read the laboratory's directions before obtaining the specimens.
10. Nitrazine paper, available through various mail order catalogues offering medical or chemistry supplies, for checking the pH of vaginal secretions. This must be specific for pH greater than or less than 4.5; a different range is used for testing amniotic fluid. Take care to avoid cervical and menstrual secretions when testing pH as these tend to be alkaline (McCue, 1989).
11. A selection of vaginal speculums. The Graves (duckbill) speculum (Fig. 22-3) comes in various widths and lengths. The Pederson speculum, which is narrower and flatter, can be used in virginal patients and those with a narrow introitus due to senescence, scars, or radiation; some physicians prefer to use it for most patients. Disposable plastic speculums have the advantage that the vaginal wall can be seen through the speculum. However, the ratchets do not permit as fine an adjustment as the screw on the metal speculums. The plastic speculum shown in Fig. 22-1 is her patient's choice, according to Dr Devra Marcus of Washington, DC.
12. Guaiac card for testing the stool for occult blood.
13. A microscope, some 10% KOH solution, and a Gram stain kit (see Chapter 28). The microscopic examination of any abnormal vaginal discharge should be considered an intrinsic part of the physical examination. Unfortunately, the so-called Clinical Laboratory Improvement Act has caused these very useful aids to disappear from many offices and clinics.

Figure 22-2 Oven mitts can serve as coverings for the stirrups.

A Self-study

Before attempting to examine a patient, the neophyte physician needs to examine the speculum and to practice manipulating it. Move the distal ends of the blades apart (like a duckbill) by pushing on the thumbpiece (which elevates the anterior blade) and pulling on the handle with your fingers (to lower the posterior blade). The blades are then held in position by tightening the screw located laterally. The center set screw allows for adjustment of the distance between the proximal ends of the blades (Fig. 22-3).

Preparing for the Examination

A few simple courtesies can make the examination less distressing to the patient and easier for the doctor. Besides the obvious humanitarian considerations, it is not possible to do a good examination of a patient who is uncomfortable and tense.

Whenever possible, interview the patient while she is fully dressed, preferably in a consultation room. Never introduce yourself to the patient for the first time while she is in the stirrups, unless forced by circumstances such as precipitous delivery or other emergency. Even if you are simply being asked to confirm a finding on the pelvic examination, the patient should at least be allowed to sit up for the introduction (Magee, 1975). Provide for adequate draping. The double draping technique described in Chapter 15, with the gown opening in the back, permits the upper body to be well covered during the pelvic examination. The sheet is draped over the patient's abdomen and knees.

It is best to have a female attendant present during the examination, even if the physician is a woman, to reassure the patient and to help with the procedure. For male physicians, this is absolutely necessary. If a patient accuses a physician of sexual harassment or assault, the testimony of the attendant may be the best defense. (Dr Sara Imershein states that some patients object to the presence of any chaperone as they feel inhibited about discussing personal concerns. To them, the presence of a third person may imply that the physician does not trust the patient. Physicians must be sensitive to their patients but they should not allow themselves to be manipulated; they should follow their own best judgment. To facilitate discussion of personal concerns, physicians should see the patient at least briefly after the examination, with the patient fully dressed and without other persons in the room.)

Before you begin the examination, the patient should be given the opportunity to go to the bathroom. A full bladder can obscure or be confused with pelvic pathology. Similarly, a full rectum can make the examination inconclusive. (If there is any difficulty in distinguishing hard stool from an area of nodularity, the patient would have to be reexamined after emptying the rectum anyway.)

The dorsal lithotomy position is preferred (i.e., feet in the stirrups, hips abducted as widely as possible, buttocks at the very edge of the table). In patients who are unable to abduct the hips, the Sims position may be used (the patient on her side, with the lower arm behind the back and the thighs flexed, the upper more than the lower.)

It should be a matter of simple common sense that an attendant should never put the patient in the dorsal lithotomy position and then leave her alone in the room.

Order of Examination

It is assumed that the rest of the examination has already been done, at least the examination of the thyroid, breasts, and abdomen.

The pelvic examination begins with inspection and palpation of the external genitalia. Next, the vagina and cervix are gently palpated with one gloved finger, lubricated with warm water or water-soluble gel, enabling the examiner to determine the direction in which to point the speculum. Also, clues to vaginal pathology may be felt. (In some instances, the need for gynecologic consultation will become obvious at this point, and the patient can be spared a second speculum examination.) The vagina and cervix are inspected with the aid of the speculum, and specimens for cytologic and microbiologic examination are obtained. Then the internal genitalia are palpated bimanually, between the abdominal wall and the fingers within the vagina. In most instances, the rectal examination concludes the examination. Sometimes, it may be desirable also to examine the standing patient to reveal a prolapse or hernia that was not apparent in the dorsal lithotomy position. While the patient is dressing, the physician carries out the microscopic examination of the cervical and vaginal secretions, if indicated.

A Note on Examining Children

A full discussion of the pediatric examination is beyond the scope of this text. However, because all physicians are required by law to report suspected child abuse, some of the issues will be outlined briefly here.

The genital examination of a child must be carried out in a gentle, nonthreatening, sensitive manner. Generally, an external examination will suffice. Girls younger than 4 or 5 years can be examined in a semireclining position in the parent's lap, with knees bent and soles of the feet touching. The labia, vestibule, and posterior fourchette can be examined by separating the labia with the fingertips in a lateral and downward direction. The interior of the vaginal canal can be seen better by gently and firmly grasping the labia majora between index fingers and thumb and pulling outward and slightly upward until the edges of the hymen separate. The prone knee-chest position provides excellent visualization of the vaginal canal and provides access for obtaining cultures, if indicated, without the need for instrumentation. The examiner's thumbs, placed beneath the leading edge of the gluteus maximus at the level of the introitus, can be used to lift the perineal body and provide exposure of the introitus (McCann, 1990). A handheld otoscope can provide both light and magnification if needed (Adams, 1991).

Sometimes the best way to examine a child is under anesthesia. If abuse is being considered, the best qualified person should do the examination in the first place as repetition is needlessly traumatic (R. Allen, *personal communication*, 2004).

External Genitalia

Pubic Hair

The appearance of a male-type escutcheon (see Chapter 7) can be a virilizing sign. However, there is normally a continuum, and a family history may be helpful. Terminal[1] hair was found on the abdomen (above the pubic triangle) of 35% of 400 English and Welsh university women (McKnight, 1964).

In patients afflicted with pubic lice, nits may be seen at the base of the hairs, along with signs of excoriation of the skin.

The Vulva

Labia Majora

The skin covering the labia majora may be afflicted with the same lesions as the skin of the rest of the body, including malignant melanomas, psoriasis, and seborrheic dermatitis. The labia are particularly rich in sebaceous glands, and hence are subject to sebaceous retention cysts and hair follicle infections. The apocrine glands may be afflicted with hidradenitis suppurativa (Fox–Fordyce

[1] Terminal hairs are coarse, dark, and long. Normally, they develop only in certain areas such as the axilla, scalp, pubic triangle or diamond, and beard.

disease). Also check for condylomata and lesions of molluscum contagiosum.

Because the labia majora are the analog of the scrotum, the occurrence of labioinguinal hernias, although rare, should not be surprising. In certain hermaphrodites, testicles are found in the labia majora.

An abscess of the Bartholin[2] gland, when fully formed, is an obvious tender red mass in the posterior labium. Patients will walk in a peculiar way and complain of severe pain. However, considerable enlargement of the gland (as from a retention cyst or rarely an adenocarcinoma) can be missed unless it is searched for. Palpate the posterior part of the labia majora between the finger and thumb, searching for a swelling. In patients with a Bartholin abscess, there is a high incidence of sexually transmitted disease (STD); Gram stain and cultures for gonorrhea and *Chlamydia* should be performed, and diagnostic tests for syphilis, human immunodeficiency virus (HIV), and hepatitis B should be considered.

Hypertrophy of the labia majora occurs in lipodystrophy.

Labia Minora

Simple adherence of the labia minora (labial agglutination or labial adhesions) in young girls is to be distinguished from imperforate hymen and congenital absence of the vagina. In one study, the incidence was fivefold higher (2.9%) in children who were proven victims of sexual abuse (Muram, 1988). However, in a study of prepubertal girls selected for nonabuse, labial adhesions were detected in 35 of 90 subjects. More than 50% of these adhesions were less than 2 mm in length and detected only on review of magnified colposcopic images (McCann et al., 1990).

Check for condylomata, herpetic lesions, and erythema.

The Clitoris

Enlargement of the clitoris is an unmistakable sign of virilization. The adult clitoral index, defined as the vertical times the horizontal dimensions, is normally from 9 to 35 mm (Rittmaster and Loriaux, 1987). Borderline values, often seen in idiopathic hirsutism, are from 36 to 99 mm. If the index is 100 mm or more, it is a sign of severe hyperandrogenicity (Tagatz et al., 1979), and demands an explanation. In the infant, clitoral enlargement may signal an adrenogenital syndrome or a maternal ovarian tumor.

The Urethra

A purulent discharge from the urethra can result from gonorrhea, a urethral diverticulum, or another cause of urethritis. Sometimes the discharge is apparent only after stroking the anterior vaginal wall in the direction of the meatus. A urethral caruncle, a tender, inflamed red mass at the meatus, may be a complication of urethritis. A prolapsed urethra may form a hemorrhagic, painful mass, superficially resembling a cancer because of its friability. The condition may occur in children or elderly women, especially after straining. In gonorrhea, pus may be expressed from the ducts of Skene glands located just lateral and somewhat posterior to the urethral orifice. They may be quite difficult to see.

Advanced. A special maneuver in a woman complaining of urinary incontinence is to place a lubricated cotton swab in the urethra to the level of the bladder neck while she is in the lithotomy position. Ask her to perform a Valsalva maneuver, and measure the change in the axis of the free end of the swab. It should remain horizontal if no anatomical defect is present. A positive test is not very helpful, but a negative one decreases the likelihood of stress incontinence (negative likelihood ratio 0.41). The Q tip test is primarily used by specialists as part of an evaluation for incontinence surgery (Holroyd-Leduc et al., 2008).

The Hymen

Inspection of the genitalia should be part of the examination of all infant girls in order to check for the presence of a vagina and for imperforate hymen. In the event of the latter, performance of a rectal examination with the little finger may reveal a bulging in the vagina due to an accumulation of endocervical mucus (hydrocolpos) from maternal hormone secretion. This bulge can become very large and has led to laparotomy for "abdominal mass" (Green, 1971). An imperforate hymen is an indication for an ultrasound examination.

Imperforate hymen should be ruled out in adolescent girls with abdominal pain. Painful hematocolpos and hematosalpinx, sometimes with rupture into the abdomen, have resulted from failure to recognize this condition before several menstrual periods have occurred. Even before menarche, mucus accumulation behind an imperforate hymen has on rare occasions caused obstruction of the ureters and bilateral hydronephrosis.

An excessive amount of tough, fibrous tissue can be the cause of dyspareunia.

Hymenal changes attributed to sexual abuse are discussed below.

Sexually Transmitted Diseases

Lesions that can occur on the penis (see Chapter 21) can also occur on the vulva or inside the vagina. These lesions include the primary chancre of syphilis (Fig. 22-4), the lesion of lymphogranuloma venereum, granuloma inguinale, chancroid, the ulcerating vesicles of herpes, condylomata lata (due to secondary syphilis; Fig. 22-5), and condylomata acuminata (venereal warts; Fig 22-4).

Condylomata acuminata are variably sized, flesh colored to purplish papillomatous growths generally confined to the anogenital region. Giant, nodular lesions with a strawberry-like surface may occasionally be seen in children. Perianal or vulvar lesions may also be associated with warts in the anal canal or in the vagina or cervix.

Condylomata may be flat and visible only with application of dilute acetic acid, or under the colposcope. A careful search is part of the workup for persistent vulvovaginitis; clearing up one condition helps to clear the other (R. Allen, *personal communication*, 2004).

Condylomata acuminata are caused by the human papilloma virus (HPV), some serotypes of which have been implicated in

[2] Casper Bartholin, the third in a line of famous Danish physicians, also described the Bartholin duct from the sublingual gland. His father, Thomas, was the rediscoverer of the lymph nodes. Thomas's father, who was also named Casper, was a polymath from Malmo who accepted the Chair in Medicine at Copenhagen (and later the one in Theology) after refusing chairs in Philosophy, Anatomy, and Greek! There is no record of any of them having served on a committee.

FIGURE 22-4 Condylomata acuminata and a chancre due to primary syphilis. This is a reminder that patients with one sexually transmitted disease (STD) frequently have one or more others also. (Courtesy of Division of Sexually Transmitted Diseases, Center for Prevention Services, Centers for Disease Control, Atlanta, GA.)

FIGURE 22-5 Vulvar condylomata lata due to secondary syphilis in a child who had been sexually molested. (Courtesy of Division of Sexually Transmitted Diseases, Center for Prevention Services, Centers for Disease Control, Atlanta, GA.)

the recent increased incidence of cervical carcinoma, especially in younger women (Raymond, 1987a,b), as well as vulvar carcinoma (*vide infra*). The prevalence of HPV in asymptomatic, sexually active young women is 20% to 40%, using amplified or nonamplified DNA hybridization methods to detect the virus (Ansink, 1996).

There is an increased incidence of genital warts in persons seropositive for HIV (Boyd, 1990). Thus, this lesion suggests the need to be on the alert for accompanying conditions, including sexual abuse in children (*vide infra*).

A diffuse reddening and edema of the vulva may result from the presence of certain types of vaginal discharge (Table 22.1).

Gonorrheal vaginitis may be distinguished by its tendency to involve the urethra, the vulvovaginal glands, and the Bartholin and Skene glands.

Evidence of one STD should raise the index of suspicion for others, especially those that are often asymptomatic for long periods, such as *Chlamydia*. Cultures or even presumptive treatment may be indicated to prevent long-term complications such as infertility.

With increased sexual activity with more partners at younger ages, the prevalence of STDs is very high. More than one in five Americans over the age of 12 is infected with genital herpes, and less than 10% of those who tested positive in a household survey realized that they were infected. Silent spread of the infection is the rule. The prevalence increased by 30% from the late 1970s to early 1990s (Fleming et al., 1997). Most striking is the increase in young persons: seroprevalence quintupled in white teenagers and doubled in white persons in their twenties (Arvin and Prober, 1997).

For further discussion of STDs, see the section on "Vaginal Discharge" below.

Condom Use

Although meticulous use of condoms is advocated, the efficacy of condoms in preventing transmission of all potential infectious agents is not precisely known and it is certainly far from perfect. In one study of participants with known gonococcal or chlamydial exposure, consistent use of condoms effected a reduction in prevalence of gonorrhea and chlamydia from 43% to 30% (Warner et al., 2004). Data are limited on the effectiveness of female condoms at preventing STDs. In a study of female patients attending an STD clinic, postintervention STD incidence (of early syphilis, gonorrhea, chlamydia, or trichomoniasis) per 100 woman-months of observation was 6.8 in the female condom group and 8.5 in the male condom group. The difference was not statistically significant (French et al., 2003).

A review of published studies on the effect of condom use on transmission of HPV found that all methods had significant limitations. Three studies found a protective effect, but most did not (CDC, 2004).

Although physicians will inquire about condom use, they should not allow assurances about consistent use to impede a careful search for STDs. Nor should they overstate the effectiveness of condoms when counseling patients about sexual activity. Sexual intercourse is an extremely effective mechanism for transferring biologic material for the perpetuation of the species. No technology has come close to equalling the effectiveness of monogamy, sexual fidelity, and premarital abstinence in curtailing the spread of STDs.

Other Infectious Diseases Affecting the Vulva

The vulva may be involved by parasites such as pinworms (especially in children) or scabies. Impetigo, a staphylococcal and/or streptococcal lesion characterized by yellow-crusted erosions, is a common accompaniment of scabies (Whiting, 1983).

Numerous fungi are saprophytes in the vulvar area and may become pathogens under conditions of lowered resistance, increased heat, or friction. Predisposing conditions include pregnancy, diabetes, oral contraceptives, and the use of broad-spectrum antibiotics. The most common fungi are tinea cruris and *Candida* (monilia). The rash of tinea cruris tends to have a butterfly

TABLE **22.1** *Differential diagnosis of vaginal discharge*

Etiology	Odor	Appearance of discharge	Appearance of vulva/vagina	pH	Microscopic findings	Symptoms
Normal	—	Thick	Pink	3.8–4.2	Lactobacilli	—
Candida	—	Curdy, white	Erythema, edema	4.0–4.7	Pseudohyphae on KOH prep.; budding yeast on Gram stain	Itching, burning
Trichomonas vaginalis	Fishy	Green, yellow, gray, may be frothy	Diffuse erythema or "strawberry vagina" or gray pseudomembrane	5.0–5.5	Motile organisms; many white blood cells (WBCs)	Itching, unpleasant odor or discharge, dysuria
Gardnerella vaginalis	Fishy	Thin, "flour paste," frothy in <10%	Usually no gross vulvovaginitis	5.0–5.5	Clue cells; lactobacilli eliminated; few WBCs unless another infection present	Few have irritation
Gonococcus	—	Purulent	Bartholinitis, skenitis, pelvic inflammatory disease (PID) may be present		Gram-negative intracellular diplococci	May have dysuria, acute abdominal pain if PID develops
Senescent vaginitis	—	Mucoid	Smooth, shiny, lacking rugae; pale; telangiectasia	5.5–7.0	Parabasal cells, WBCs, various bacteria, "dirty" background	Burning, itching, dyspareunia

appearance, with clearly defined, raised, scaly borders, also affecting the upper, inner thighs. A curdy, white vaginal discharge is diagnostic of candidal vulvitis. There may be red maculopapular lesions, "satellite lesions," lying beyond the border of the inflamed area. However, the characteristic discharge is present in fewer than 50% of the cases; more often, there is redness, possibly a watery discharge, and intense discomfort (R. Allen, *personal communication*, 2004).

Ulcerations of the vulva and vagina can be caused by *Entamoeba histolytica* (generally after a bout of uncontrolled diarrhea).

Other Systemic Diseases

Draining sinuses, abscesses, and deep ulcerations may result from Crohn disease. Other conditions causing vulvar ulcers include Behçet disease, pemphigus vulgaris, dermatitis herpetiformis, and erythema multiforme.

Atrophic Vulvitis

After menopause, the labia may shrink and flatten because of the loss of subcutaneous fat. The skin becomes thin and shiny, and elasticity diminishes. Changes of a similar nature generally coexist in the vagina (*vide infra*), and the vaginal orifice may become stenotic.

Vulvar Dystrophies

Vulvar skin is more sensitive to irritants than peripheral skin, and, additionally, is exposed to a wide variety of potential sensitizers and irritants, such as laundry powders, douches, contraceptive creams, and deodorants (Friedrich, 1985). A long-standing itch–scratch cycle can cause a hyperplastic dystrophy, which is a variant of lichen simplex chronicus (neurodermatitis). This may produce a diffuse erythema, or localized, elevated lesions, often with a white appearance due to hyperkeratosis. Chronic irritation is also thought to cause malignant changes.

Lichen sclerosus (also called *lichen sclerosus et atrophicus*) typically produces white to pearly flat macules, which may coalesce into plaques, involving the vulva, medial thigh, and/or perianal region. The skin may come to resemble parchment or cigarette paper. Agglutination and fusion of the interlabial folds and a concentric stenosis of the introitus may occur. Half to two thirds of the patients are postmenopausal, but the disease does occur in children (of whom only 35% have genital lesions). Extragenital sites such as the axilla may be involved. A 34% incidence of clinically manifest autoimmune diseases has been reported in patients with this condition (Soper and Creasman, 1986).

Carcinoma develops in about 3% of patients with lichen sclerosus (Soper and Creasman, 1986). Conversely, lichen sclerosus was an associated lesion in 16 of 30 (53%) patients with invasive vulvar carcinoma (Punnonen et al., 1985).

At the time of presentation, 2% to 5% of women with a vulvar dystrophy have an invasive carcinoma of the vulva, and an additional 4% to 8% have some cellular atypia (Soper and Creasman, 1986).

Carcinoma In Situ of the Vulva

The lesions of squamous cell carcinoma in situ (sometimes referred to by the ambiguous terms Bowen disease or erythroplasia of Queyrat) can be unifocal or multifocal and discrete or coalescent. About 20% of the lesions are pigmented; the remainder are white or red. The relationship of the lesions to invasive carcinoma is not as strong as that with cervical carcinoma in situ. Previously considered

a disease of older women, there is an increasing incidence in younger women, with cases occurring in women as young as 17 (Al-Ghamdi et al., 2002) years. Between the periods 1985–1988 and 1994–1997, the incidence of high-grade vulvar intraepithelial neoplasia in women aged 50 or under increased by 392%, and the incidence of invasive vulvar cancer by 157% (Joura et al., 2000). Most but not all tumors are associated with HPV. Suspicious lesions must be biopsied.

Paget Disease

Although formerly considered synonymous with carcinoma in situ, Paget disease of the vulva is a separate entity (Nichols and Evrard, 1985), an intraepithelial adenocarcinoma, occasionally associated with an underlying invasive adenocarcinoma. It presents as a sharply demarcated, florid, red, pruritic, moist area, with occasional crusting. Islands of whitened skin appear between the reddened areas. The lesion may spread to the perineum and thighs.

Invasive Carcinoma of the Vulva

Vulvar cancer is extremely variable in appearance. In its early form, it may be an elevated papule or a small ulcer and may be easily confused with condyloma acuminatum, papillomata, ulcerated chancroid, gumma, or tuberculosis. (Thus, biopsy is very important.) A typical later lesion is an ulcerating mass. Previously, about 70% of patients were postmenopausal (Kistner, 1986), but younger women are now more commonly afflicted, consequent to changes in sexual mores (*vide supra*).

A Note of Caution

All too often, treatment of a serious vulvar condition is delayed because of "trying" various treatments: empiric treatment of yeast, of gardnerella, and so forth, when what is needed is a comprehensive vulvar examination with a colposcope, possibly with cultures and biopsies (R. Allen, *personal communication*, 2004).

Trauma

A very large hematoma may result from trauma, such as falling astride a hard object. If there is evidence of trauma without a persuasive history, the possibility of rape or sexual abuse must be considered.

Sexual Abuse

In recent years, there has been a substantial increase in reports of childhood sexual abuse as well as child abuse and neglect in general. (There was no subject heading for "child abuse" in the *Index Medicus* until 1965.) There have also been notorious incidents in which persons later determined to be innocent were convicted of highly implausible offenses on the basis of tainted evidence. The consequences of missing the diagnosis or of making an unfounded accusation are both devastating. In the latter instance, the children as well as the accused may be harmed, as by unwarranted separation from parents and stressful interviews that may have effects akin to exposing the child to pornography (Zeitlin, 1987). Support has been presented on both sides of the question as to whether abuse is overdiagnosed or underdiagnosed (Jenkins and Howell, 1994). It is said that for all investigated cases, the rate of validation is no more than 50%, or 70% if the source of the allegation is the child or a parent (Zeitlin, 1987). As in investigating for the presence of any disease, one must remember that as the prevalence of a condition decreases (say because a broader population is being examined), the predictive value of a positive test also decreases.

In examining any patient in whom rape or sexual abuse is a possibility, particularly within 72 hours of the alleged event, a medicolegal protocol must be strictly followed in order to collect evidence required by the court (such as the presence of semen and signs of the use of force). Consultation with a physician experienced in these issues is advisable.

Definite physical evidence of sexual contact or abuse consists of a finding of semen or sperm on a child's body; nonaccidental, blunt penetrating injury to the vaginal or anal orifice; or positive, confirmed cultures for *Neisseria gonorrhea* (with caveats discussed below); or serologic confirmation of acquired syphilis (Adams et al., 1994).

Semen is most useful, both for demonstrating that a sexual event occurred, and, with the availability of DNA testing, establishing the guilt or innocence of a suspect. However, it is unlikely to be found if more than 72 hours have elapsed since the assault, and may also be lost if the child has washed, urinated, or defecated (Bays and Chadwick, 1993). Fewer than 10% of preadolescent victims will be seen within that time frame (Reinhart, 1991). Physical evidence of probable abuse includes culture-proven infection with *Chlamydia trachomatis* in a prepubertal child older than 2 years, proven herpes simplex type 2 (unless acquired perinatally), or documented *Trichomonas* infection (Adams et al., 1994).

The evidentiary value of STDs is frequently in dispute because of issues of perinatal or nonsexual transmission (Reinhart, 1991), especially in view of the high and increasing prevalence of various STDs in young women of childbearing age, such as venereal warts, *Chlamydia*, and herpes. Gonorrhea may be transmitted perinatally, although in this instance it generally manifests within a few days of birth (Reinhart, 1991). Inoculation of the gonococcus by fingers or towels is reportedly possible in children because of the greater susceptibility of the thin immature mucosa and the alkaline pH of the vagina (Monif, 1982). *Chlamydia* acquired at birth can persist for 2 to 3 years in genital, anal, or pharyngeal sites. *Chlamydia* is an obligate intracellular parasite; fomite transmission has never been demonstrated (Bays and Chadwick, 1993). The presence of anogenital condylomata or warts raises the index of suspicion of abuse; however, this increasingly common infection has been shown to be transmitted by tub baths; bidets; or the sharing of beds, towels, or underwear (Pacheco et al., 1991). If acquired perinatally, the HPV can remain latent for up to 8 months of age (Bays and Chadwick, 1993). Genital molluscum contagiosum also raises the index of suspicion, but it is a common disease that can be spread by direct contact, autoinoculation, or fomites (McIntyre, 1986). Corroborative evidence of sexual abuse was found in 75% of patients from whom *Gardnerella vaginalis* was isolated (Argent et al., 1995). *Trichomonas vaginalis* can also be transmitted nonvenereally (*vide infra*).

False negatives are common on physical examination. One study reported that in legally confirmed cases of sexual abuse, the

female genital examination was normal in 28% of cases, nonspecific in 49%, suspicious in 9%, and definitely abnormal in only 14% (Adams et al., 1994). Genital trauma, STDs, or sperm have been found in only 3% to 16% of child victims (Bays and Chadwick, 1993). Injuries heal rapidly in children. The frequency of abnormal findings ranged from 69% within 3 days of the last episode to 15% in more than 6 months after the last episode (Adams and Knudson, 1996). Significant lacerations of the posterior fourchette and perianal tissues have reportedly healed completely within 7 to 10 days (Adams, 1992).

There are wide variations in the normal anatomy of healthy, nonabused premenarchal girls. Such girls exhibit a high frequency of minor irregularities sometimes attributed to sexual abuse, including increased vascularity of the hymen (44%), midline avascular areas (27%), "ragged" posterior fourchette epithelium (18%), notch configuration of the fourchette (10%), delicate tethers between the hymen and perihymen (14%), hymenal bumps between the 3 and 9 o'clock positions (11%), and asymmetry of the hymenal tissue (9%) (Gardner, 1992).

Lichen sclerosus et atrophicus (*vide supra*), with or without superimposed infection (Handfield-Jones et al., 1987), is the most common dermatologic condition that is confused with sexual abuse. It can cause alarming subepidermal hemorrhages after minor trauma such as wiping (Bays and Chadwick, 1993), as well as bruises, erosions, and ulcerations (Mühlendahl, 1996). Other conditions that have been confused with sexual abuse include congenital epispadias, vaginal hemangioma, urethral caruncle, congenital pit, diaper dermatitis, straddle injury (West et al., 1989), seat-belt injury, irritation from substances such as bubble bath or too vigorous scrubbing (Adams, 1991), and unusual adhesions and scars due to female circumcision in patients of African or Middle Eastern origin (Bays and Jenny, 1990).

Much has been made of the diameter of the hymenal orifice as evidence for and against penetration. However, the average difference in diameter in abused versus nonabused girls aged 3 to 6 years was only 1.6 mm, possibly within the error of measurement. Moreover, the standard deviation in uninjured 6-year-olds was found to be about 2 mm (Claytor et al., 1989). Using 4 mm as a cutoff, as has been suggested, the predictive value of a positive test is only about 27% in a population with a 10% prevalence of abuse involving penile or digital penetration. Conversely, the test was negative in 26% of girls describing penetration (Paradise, 1989). It is hypothesized that all adolescent girls who are neither abused nor sexually active have a posterior hymenal ring wider than 1 or 2 mm. Further evidence for this statement is being sought (Adams and Knudson, 1996).

It is important to realize that measurements can be influenced by many factors, including the position of the child during measurement, the degree of traction placed on the external genitalia, and the degree of the child's relaxation. Normal diameter is also a function of age, increasing by about 1 mm per year in uninjured girls, and possibly losing age-related variability in abused girls because of scarring (Claytor et al., 1989).

The widespread belief that the hymen ruptures, with bleeding, on first intercourse, and that a physician can tell by inspecting a hymen whether or not penetration has occurred, is a myth: The hymen is an extremely elastic tissue.

The presence of a vaginal discharge in a prepubertal girl, or the presence of deep notches and transections of the posterior hymen, or hymenal transection, support the suspicion of sexual abuse. An extensive literature review concluded, however, that the accuracy of most genital findings used in isolation was poor for predicting sexual abuse. Research is "challenging," and only two studies met criteria for reliable data on diagnostic accuracy (Berkoff et al., 2008).

Before undertaking overzealous examinations, the physician should remember that the application of a millimeter ruler to a child's genitalia, even if the measurements were totally reliable, can have many unanticipated consequences (Heger and Emans, 1990), including the effects of an embarrassing and intrusive examination, especially when unwarranted.

The most important evidence in a child abuse case is the history. To be valid, this must be obtained in a calm, sensitive manner without "leading the witness." Interviewers must remain objective; all too frequently, the very titles chosen for examiners, such as "validators" or "corroborators," suggest bias. Such persons should be called, and should think of themselves, as "examiners" or "evaluators" (Jenkins and Howell, 1994). If "disclosure" is not forthcoming, it is not necessarily indicative of "denial."

Keep in mind that repetitive questioning, or poor questioning, can taint the answers.

Additionally, the interview of the victim must not be turned into an interrogation (see Chapter 2). To help guard against this possibility as well as to provide a means for later review of the evidence in criminal proceedings, interviews should be videotaped. In one investigation, almost 25% of children answering a questionnaire saw an assessment interview as being harmful in some way, and intense investigatory interest in sexual matters may be perceived by a child as little different from the abuse that may have occurred (Zeitlin, 1987).

Be aware that this area is very controversial and that findings are likely to be challenged in litigation. Early assistance from persons with special skill and training should be considered.

Vaginal Examination

External Inspection

Several types of hernias may present as a bulge covered with vaginal mucosa at the introitus. Redundant vaginal mucosa may resemble such a hernia. (This might be referred to as a colpocele, a term some consider obsolete.) A cystocele contains part of the bladder, and a rectocele contains part of the rectum. An enterocele is a herniation of the peritoneal lining of the posterior cul-de-sac into the posterior vaginal fornix, which can also protrude beyond the introitus in severe cases. Asking the patient to strain, cough, or bear down may make any of these hernias more apparent, as will an examination in the standing position. In extreme cases, the cervix will prolapse through the introitus. All these abnormalities result from relaxation of the endopelvic fascia, usually due to childbirth.

Rarely, an obturator hernia will form a bulge in the vaginal wall; this is more likely to be felt than seen (*vide infra*).

Palpation

As noted above, a digital examination of the vagina may precede the insertion of the speculum. (Some physicians omit this step once they have become skilled in using the speculum.) Avoid pressure on the sensitive anterior structures (urethral meatus and clitoris) when inserting your finger. Lubricate the glove with water or a water-soluble gel unless the laboratory interpreting the Pap smear objects to the latter.

It is important to talk to the patient and explain to her what you are going to do before you do it. For example, "I'm going to touch the outside of your vagina and spread it apart. Now, I'm going to put my finger in" (Magee, 1975). It is generally not very helpful to command the patient to relax. If you push down and out from just inside the introitus, and ask her to relax the muscle you are pushing on (the levator ani), she will probably understand what you mean.

Feel all the vaginal walls, particularly the anterior fornix, which is the usual site of vaginal carcinoma. Clear-cell adenocarcinoma may present as a nodule about the size of a green pea under the vaginal vault. This may be seen in the daughters of women who took diethylstilbestrol (DES) during pregnancy. The incidence in women thus exposed is about 1:1,000, and the median age of occurrence is 19 years (Ryan et al., 1995). DES was used in the 1950s and 1960s to prevent miscarriages, and more recently as a postcoital contraceptive ("morning after" pill), which does not always prevent pregnancy.

In patients complaining of the "urethral syndrome" (retropubic pressure, urinary frequency, dysuria, and often dyspareunia, with negative urine findings), localized tenderness may be found when pressing upward against the pubic bone, lateral to the urethra. Paraurethral glands located there may be the site of "female prostatitis," which is appropriately treated with long-term use of tissue-penetrating antibiotics, rather than urethral dilation, anxiolytics, and other methods directed toward a "functional" disorder (Gittes and Nakamura, 1996).

The mouth of a rectovaginal fistula may be palpable as an area of induration in the posterior vaginal wall. A tender swelling on vaginal examination, in the region of the obturator foramen (the large rounded opening between the pubis and the ischium, palpable through the lateral wall of the vagina), can be an important clue to the diagnosis of an obturator hernia (Clain, 1973). This rare condition, which occurs almost exclusively in thin women over the age of 60, can be an obscure cause of strangulation of the bowel, frequently of the Richter[3] type. The swelling in the groin is likely to be overlooked because it is covered by the pectineus muscle. Pain may be referred along the obturator nerve and its geniculate branch to the knee (the Howship–Romberg sign) and may limit movement of the hip joint, which tends to be held in a semiflexed position (also see Chapter 26).

Pelvic floor muscle strength, important for urinary continence can be tested by asking the patient to squeeze your finger while performing the vaginal examination, as she would do to keep herself from voiding.

[3] In a Richter hernia, only a portion of the circumference of the intestine is strangulated.

Speculum Examination

A Method

1. Choose a speculum of the appropriate size on the basis of your previous inspection or digital examination. You want a speculum that will fit comfortably yet give adequate exposure. The Pederson speculum works in most cases and patients are more likely to come back (S. Imershein, *personal communication*, 1998). It will seldom be necessary to use anything larger than the medium Graves speculum even in multiparous women.
2. Before inserting a metal speculum, be sure to warm it up with some warm water, which also helps to lubricate it a little. If you think it might be a little too warm, touch it to the inner thigh and ask the patient if the temperature is comfortable for her. Another method of warming is an incandescent bulb. Plastic speculums are not as cold.
3. Seat yourself on a low stool at the foot of the examining table.
4. Some recommend inserting the instrument with the blades horizontal (Magee, 1975), although many textbooks suggest inserting the speculum with the blades vertical or on an angle and rotating it once it is inside. The main thing is to be gentle and not too quick, and to avoid scraping the blades across the urethra. Some insert the instrument right over the index and third fingers of the left hand, which are pushing down on the posterior vaginal wall. Others just use the fingers of the left hand to keep the labia apart and the pubic hair out of the way. Aim posteriorly (the object being to get the posterior blade behind the cervix), and try to avoid putting pressure on the roof of the vagina. Any pressure should be applied posteriorly.
5. After the speculum is in place, open it slowly so that you can visualize the cervix. If you are using a plastic speculum, forewarn the patient about the click that it makes when locking into place. If a greater anteroposterior exposure is needed, the central set screw of the Graves speculum may be released and the blades separated further. Be sure that this screw is again tightened securely; if the blades suddenly move closer together, they may pinch the vaginal mucosa or labia. Some examiners do not ordinarily set the lateral screw but simply hold the speculum open while obtaining the Pap specimen and slowly rotating the speculum in order to look around.
6. The cervix will seem to be much more conveniently located in the second thousand patients that you examine than in the first thousand. If you cannot see it at first, and you are using the right size speculum, it may be hiding behind either the anterior or the posterior blade of the speculum. The longer posterior blade is supposed to act as a scoop to slide the cervix between the two blades as the speculum is opened. You may have to withdraw the speculum a little to look behind the anterior blade, and then possibly insert it deeper and more posteriorly. In cases of redundant vaginal mucosa or a retroverted uterus, a "pusher" (which might be made of a cotton pledget held in a curved uterine dressing forceps) may help to expose the cervix (Green, 1971).
7. Look at the cervix for signs of disease (*vide infra*).

8. Obtain a Pap[4] smear from the posterior vaginal pool of secretions with a wooden scraper, and another from the cervix: Wipe off any heavy mucus from the cervix, then insert the cervical brush or other collection device into the endocervical canal, and rotate it a full 360 degrees. Some state that you should see punctate bleeding as evidence that an adequate specimen has been obtained (Demarest, 1985). Others note that the bleeding may be a sign of chlamydial infection (F. Abbas, *personal communication*, 1987). Check your Pap smear reports; if they do not specifically state that endocervical cells are seen, reevaluate your technique.
9. Spread the specimen onto a glass slide, which has been labeled with the patient's name, and *immediately* spray it with fixative or follow other directions supplied by the laboratory. Deterioration of the cells occurs rather rapidly.
10. Obtain specimens for gonococcal culture or other microbiologic evaluation if indicated by the history. (In a patient population with a high incidence of STD, this may be done routinely in all patients.) Place a sterile swab in the endocervical canal and rotate it. Count slowly to 30, then remove the swab, and inoculate the transport medium as directed. (Remember that it may need to be warmed to room temperature.) Obtain other specimens as indicated by the history or by the epidemiologic setting, for example, for *Chlamydia*, according to the directions supplied by the laboratory.
11. When clinically indicated, make two slides of vaginal secretions to examine yourself as quickly as possible, a wet mount and a thin smear for Gram stain. Some place a drop of normal saline on the slide for a wet mount, but a small drop of secretions under a coverslip may be just as satisfactory. Place a drop of secretions on some nitrazine paper for determining the pH (Table 22.1). If more than a few minutes will elapse before you can get to a microscope, place the wet mount under an incandescent lamp to keep it warm, so that trichomonads, if present, do not lose their motility. Dr Sara Imershein takes a swab and places it in a test tube to be used for making a slide in the laboratory: one side with a drop of 0.9% saline and the other with a drop of KOH.
12. Look at the vaginal mucosa carefully, especially as you begin to withdraw the speculum. As before, be certain that any pressure is exerted posteriorly rather than anteriorly. Release only the lateral set screw, to allow the tips of the blades to come together as the speculum is withdrawn, *not* the central set screw (because releasing the latter might cause the blades to pinch the vaginal mucosa.)
13. Perform the bimanual examination (*vide infra*).

How Often Should a Pap Smear Be Done?

The frequency with which Pap smears should be taken for routine screening has been the subject of controversy. The American Cancer Society once recommended routine smears only every 3 years, once three consecutive annual smears were negative, whereas the American College of Obstetrics and Gynecology recommended annual screening (Gunby, 1980).

The appropriate interval depends on the natural history of the disease, especially the duration of the detectable preclinical phase, the sensitivity of the test, and the patient's risk. Unfortunately, the sensitivity of the Pap smear is only about 80% to 85% (Ryan et al., 1995). Moreover, the progression from mild dysplasia to frank carcinoma may be much more rapid than previously thought (Raymond, 1987a), especially in a subset of patients (Miller et al., 2003).

Physicians should take the individual patient's risk into account when making a recommendation. Women with multiple sexual partners or a history of an abnormality obviously need more frequent examination. Carcinoma of the cervix is an STD. Although deaths from cervical carcinoma have plummeted owing to Pap smears, the risk of cervical intraepithelial neoplasia has almost doubled in women born since about 1940, almost certainly because of changes in sexual behavior consequent to the availability of oral contraceptives (Herbert, 2000). The HPV vaccine does not obviate the need for screening.

All of this debate could be rendered moot if the Pap smear is replaced by newer, more sensitive technology (Davey, 2003; DeMay, 2000). But currently, the Pap smear yields fewer false positives (12.3%, 95% CI 10.5–14.2) than HPV testing (Cain and Howett, 2000).

The Cervix

The ectocervix is covered by pink squamous epithelium and the endocervix by a red columnar epithelium. The location of the boundary between these two types of epithelium varies. During childhood and after menopause, the boundary is located out of view within the cervical canal. With estrogenic stimulation, the boundary may migrate so that the columnar epithelium is visible. This cervical eversion or ectropion may be confused with cervical erosion, a term that implies denudation of the epithelium.

Endocervical glands may become plugged, forming mutinous retention (nabothian) cysts. These are visible as spherical elevations or small cysts 2 to 10 mm in diameter. They are of no pathologic significance. The cervical os is round in a nulliparous woman. After childbirth, the os may appear slitlike, or may be distorted in shape by scarring if lacerations occurred. A patulous (Latin for "distended, spread apart") cervix may be a sign of recent abortion (spontaneous or induced) but may also be seen in multiparous women.

Polyps may be seen protruding from the cervix.

Chronic cervicitis, defined as epithelial necrosis and neutrophils, has been found in about 98% of cervices (Kistner, 1986). Clinically significant cervicitis may show a beefy, friable cervix with a mucopurulent discharge (Levin et al., 1987). (This will appear yellow on a white cotton swab.)

[4] "Pap" was the nickname of the method's inventor, George Nicholas Papanicolaou, MD (Athens), PhD (Munich). After the Balkan war, he emigrated to the United States, where he was working as a rug salesman in a department store, when he finally secured a position as instructor in anatomy at Cornell. While using exfoliative cytology to study female endocrinology, he noticed that cancer cells stained differently. He presented and published in the Proceedings of the Third Race Betterment Conference, Battle Creek, Michigan, January 2 to 6, 1928, noting that, "It is not an exaggeration to say that certain cases of carcinoma of the cervix may be diagnosed by the presence of only one of these cells." This was ignored, and he resumed endocrinology research for a dozen years. When the Cornell dean happened to read the old paper, he encouraged Papanicolaou (then 57) to return to cancer diagnosis, with salubrious results for all. The "Pap" smear is the only eponymous nickname that I know of in medicine.

Figure 22-6 Primary syphilitic chancre on the cervix. (Courtesy of Division of Sexually Transmitted Diseases, Center for Prevention Services, Centers for Disease Control, Atlanta, GA.)

Several infectious diseases may produce cervical lesions, including syphilis (Fig. 22-6), tuberculosis, and chancroid. Herpes simplex may produce cervical inflammation, vesicles, ulcers, or occasionally, a fungating mass indistinguishable from carcinoma. Condylomata are sometimes found on the cervix. If these are not sought and treated, the result of treating vulvar condylomata will be unsatisfactory.

Although hyperkeratosis is not itself premalignant, it is frequently found in association with cervical neoplasia. Thus, all patients with white lesions of the cervix should be biopsied. A bluish appearance of the vagina and introitus, the Chadwick sign of pregnancy, usually appears near the end of the second month. This sign was first described by Jacquemier, and so is also known by his name. A bluish appearance of the cervix is called the *Goodell sign*, an eponym that is also attached to softening of the cervix. The physical signs of pregnancy are summarized in Table 22.2. (See Chapter 6 for the rollover test of pregnancy-induced hypertension.) If you were contemplating a diagnostic or therapeutic procedure, or even writing a prescription, you would have considered the possibility of pregnancy and diagnosed it early by blood or urine test long before any of these signs appeared, especially in the medicolegal climate in the US.

In patients who have had a hysterectomy, the cervix is usually absent. (However, in former times abdominal hysterectomy was performed leaving the cervix in place.) If the cervix is absent, a smear from the vaginal vault is still recommended by some, although carcinoma of the vagina is rare (1% of all genital malignancies).

If an intrauterine device (IUD) has been inserted, check for the string emerging from the cervix. The presence of an IUD is associated with an increased incidence of pelvic inflammatory disease (PID) and of ectopic pregnancy. In the presence of infection or pregnancy, the IUD needs to be removed.

Vaginal Discharge

Vaginal discharge (or leukorrhea) is one of the most common reasons for visits to gynecologists. The major causes are listed in Table 22.1.

TABLE **22.2** *Pelvic and extrapelvic signs of pregnancy*

Name or Eponym	Description
Chloasma	"Mask of pregnancy," irregular brownish patches on the face and neck
Linea nigra	Brownish black color in midline of abdominal wall
Palmar erythema	Occurs in two thirds of white and one third of nonwhite women
Spiders, telangiectasia	Occur in about two thirds of white and 10% of black women
Epulis	A focal, highly vascular swelling of the gums
Montgomery glands	Small elevations (hypertrophic sebaceous glands) scattered through the areola
Other breast changes	Increased size and nodularity; colostrum secretion; delicate veins become visible beneath the skin; nipples become pigmented and more erectile
Ladin sign	An area of elasticity on the anterior face of the uterus just above the cervix; felt on palpation through the vagina as early as the fifth or sixth week
Hegar sign	Softening of the isthmus between cervix and uterine corpus
Goodell sign	Bluish appearance and softening of the cervix
Chadwick sign	Bluish vaginal mucosa
McDonald sign	Uterine corpus and cervix can be easily flexed on each other (because of the softening responsible for the Hegar sign)
Piskacek sign (von Braun–Fernwald sign)[a]	Asymmetry of the uterus with a well-defined soft prominence of the cornu due to implantation near one of the cornua

[a]Actually, the sign should be attributed to Robert Latou Dickinson (Munsick, 1985).

From Hellman LM, Pritchard JA. Williams Obstetrics, 14th Ed. New York, Appleton-Century-Crofts; 1971 and Danforth DN, Scott JR, eds. *Obstetrics and Gynecology*, 5th Ed. Philadelphia, PA: JB Lippincott Co; 1986, with permission.

As many as one in three women attending STD clinics may harbor *Trichomonas vaginalis* (McCue, 1989), the most common curable STD. It has been found in 17% of men attending STD and dermatology clinics in Malawi, including 11% of asymptomatic men with fewer than five white blood cells per high-power field of urine (Hobbs et al., 1999).

Although many infected persons of either sex are completely asymptomatic, women may have a profuse, irritating discharge with a fetid odor. Multiple, small, round, red papules might cover the vaginal mucosa ("strawberry vagina"). Prompt microscopic examination of the wet mount may reveal this motile, flagellated, pear-shaped protozoan, often in the company of many leukocytes. Trichomonads may resemble leukocytes, particularly if they have rounded up and lost their motility because of a delay in the examination. In 600 patients, the sensitivity of the wet mount for this diagnosis was 60%; the specificity was 100% (Krieger et al., 1988). A positive examination permits immediate treatment, but the wet mount may no longer be the diagnostic standard because a highly sensitive, affordable culture is available. As trichomoniasis has been associated with a 30% increase in preterm birth and low birth weight, detection is important even in the absence of symptoms (Hook, 1999).

The diagnosis of trichomoniasis should not be overlooked in older women, particularly institutionalized patients, as it may be transmitted nonvenereally on moist cloths and as it survives well in urine (McCue, 1989).

Candida albicans and *Candida glabrata*, which are part of the normal endogenous flora in up to 50% of asymptomatic women, very commonly cause vaginal discharge and vulvovaginitis. Candidiasis is not considered an STD (McCue, 1989). The symptoms of vulvar burning and itching may seem to be much more severe than might be expected from the amount of discharge. Predisposing conditions include diabetes, pregnancy, corticosteroids, obesity, possibly oral contraceptive use, and, perhaps most commonly, systemic antibiotic use. Severe, recurrent vaginal candidiasis has preceded development of clinically apparent acquired immunodeficiency syndrome (AIDS) (Rhoads et al., 1987). Budding yeast or pseudohyphae may be seen on the wet mount and may become more visible if 10% KOH is added. The Gram-positive organism also is easily seen on the Gram stain, being much larger than bacteria.

Bacterial vaginosis (formerly called "nonspecific vaginitis") is attributed to *Gardnerella vaginalis* (previously called *Hemophilus vaginalis*), although this organism can be cultured from 30% to 70% of healthy, asymptomatic women, and coinfecting agents may be involved (McCue, 1989). Its discharge has a fetid odor like that of trichomoniasis, so the physician could suspect the diagnosis during the examination by sniffing the speculum or the test tube containing the swab of secretions. An amine produced by the bacteria can be volatilized by adding a drop of KOH to the discharge. Smell the slide quickly—the fishy odor may be apparent only in the first whiff. On the wet mount, the vaginal epithelial cells look speckled (because of the adherent bacteria) and may appear to lose their borders. These are called *clue cells*. The Gram stain shows sheets of pleiomorphic Gram-negative coccobacilli, and a notable absence of the normal lactobacilli, which are plump Gram-positive rods.

Patients with gonorrhea often do *not* complain of a vaginal discharge, but of course the physician will look for the kidney-bean–shaped, intracellular, Gram-negative diplococci in all Gram stains. In prepubescent girls with a vaginal discharge, gonorrhea should be considered, although candidiasis is an alternate and possibly more common diagnosis. The physician who discovers gonorrhea is obliged to investigate the possibility of sexual abuse (*vide supra*).

The discharge in atrophic or senescent vaginitis, which may be white, tan, or yellow, is seldom profuse. Although this condition may cause a blood-tinged discharge, such patients need to be referred for evaluation of a coexisting endometrial carcinoma.

A vaginal foreign body should be suspected in case of a persistent, bloody, foul-smelling discharge. Small wads of toilet tissue are among the most common objects retrieved from young girls. These may be visualized in a young patient by placing the child in a prone knee-chest position (Adams, 1991).

The diagnostic tests described above fail to diagnose about 30% of women with vaginal symptoms. Likelihood ratios have been compiled (Anderson et al., 2004); few of the many published studies on vaginal complaints provide useful information on the sensitivity and specificity of various findings.

Vaginal Carcinoma

A blood-tinged discharge may be the presenting symptom of vaginal carcinoma. A polypoid mass or a fungating grapelike mass may be a sarcoma. Any polyp in the vagina of a child must be biopsied without delay because of the possibility of the extremely aggressive tumor, sarcoma botryoides.

Other Findings in the Vagina

Look for the opening of a rectovaginal fistula.

Vaginal ulcers may occur from the same etiologies as ulcers of the vulva. Transverse ridges in the vagina (or on the cervix), abnormal vaginal mucosa, and vaginal adenosis (the presence of glandular epithelium capable of secreting copious quantities of mucus) have been described in 36% to 90% of women with in utero exposure to DES (Ryan et al., 1995).

Bimanual Examination

A Method

1. Stand either at the foot of the table or at the patient's left side, outside the abducted leg.
2. Explain to the patient that you are going to feel her womb and ovaries. Ask her to "take slow, deep breaths, and try to make the abdomen very soft."
3. Use whichever hand you wish for the next step. In fact, some physicians switch intrapelvic hands halfway through so as to optimize their palpation of each adnexa.
4. Insert your index and third fingers (well lubricated with jelly) into the vagina, again taking care to avoid pressure on the anterior structures. Fold the fourth and fifth fingers into the palm, which is supine (i.e., facing upward). If the introitus is very small, you may be able to insert only the index finger.
5. Locate the cervix. You may wish to take this opportunity to tell the patient, "Your cervix is right here. It feels like the end of your nose." (Make sure that it does feel that way; *vide infra*). Remind her

that if she uses a diaphragm for contraception, she needs to check that it covers the cervix. Or if she has an IUD, she needs to check periodically to be sure its string is in place in the cervical os.

6. Place the vaginal fingers under the cervix and push it (and the uterine corpus) toward the abdominal wall. Watch the patient's face; tenderness is an important sign of PID. Place the external hand gently on the abdominal wall and feel for the fundus of the uterus, starting just under the umbilicus and proceeding toward the symphysis pubis. By palpating the uterus between the two hands, you can ascertain its size, shape, consistency, and mobility.

   If you are not able to feel the fundus of the uterus in this way, it may be retroflexed, in which case it is felt in the cul-de-sac, posterior to the cervix. Another clue to a retroflexed uterus is that the cervix tends to be almost parallel to the axis of the vagina instead of perpendicular to it.
7. To palpate the left adnexal area, move your fingers to the left of the cervix. Move the external hand just medial to the anterior superior iliac spine, and bring it over the ovary by a series of inferior displacements. Feel for the size, shape, and mobility of the ovary. Remember that ovaries, like testicles, are tender, so gentleness is very important.

   Examine the right adnexal region, *mutatis mutandis*.

   (Do not be discouraged. Palpating the ovaries is not like feeling for a coin in your pocket. It has been compared with trying to determine which grocery bag has the oranges or the hot dog buns in the middle, by feeling through the sides of the bag.)
8. The examination concludes with a rectovaginal examination. First, change your glove or remove the outer (soiled) glove from the hand to be used for the rectovaginal examination. Although gynecologists have always been careful to avoid introducing rectal organisms into the vagina, it may be equally important to keep infectious agents (e.g., lymphogranuloma venereum; HPV, the cause of venereal warts; and HIV, the cause of AIDS) out of the rectum (Wilbanks, 1986).

Inspect the anal area for hemorrhoids, fistulae, and other signs of pathology (see Chapter 23). Making sure that the fingers are well lubricated, insert the index finger into the vagina, and the third finger into the rectum.

Feel the rectovaginal septum between your two fingers for thickening and nodularity. If the uterus is retroverted, outline the fundus. Finally, move the rectal finger through 360 degrees to check for masses in the rectum (see Chapter 23). (You may remove the finger from the vagina before doing this.)

Check the stool on the glove for occult blood.

Some Pedagogic Notes

1. Gynecologists disagree on whether the abdominal hand is pushing structures toward the vaginal fingers to be examined by them, or the vaginal fingers are lifting structures to be examined by the external hand. Because the external hand is closer to the ventral side of the structures, and the internal hand to the dorsal side, both hands should be used to obtain information. It may be helpful to think of first one, and then of the other, as the "examining" hand.
2. It may be quite difficult to distinguish an adnexal mass from a uterine mass. If you apply downward pressure to a uterine mass, or move it from side to side, you should feel pressure and movement of the cervix against your fingers. If you do not, the mass may be ovarian, or a leiomyoma suspended on a long pedicle.
3. Students should never pass up an opportunity to examine a patient under anesthesia. The use of mannequins would also be very helpful in improving skill in this examination.

The Cervix

In either PID or ruptured ectopic pregnancy, the cervix will be exquisitely tender, especially with motion. This has been called the "chandelier sign," but some consider this term demeaning.

A stony hard consistency of the cervix is a sign of carcinoma. Softening is a sign of early pregnancy (see Table 22.2), but may also occur with leiomyoma.

The Uterine Corpus

The normal uterus feels like a small ripe pear. It should be firm, smooth, and freely movable.

Retrodisplacement

Although once treated with enthusiastic surgical intervention, retrodisplacement of the uterus is itself of no pathologic significance, being found in about 20% of women who presented at a large gynecologic clinic (Kistner, 1986).

Infections

On examination, the uterus may be boggy and tender. A purulent exudate may be seen coming from the cervical os. This may signal endometritis, which is often also associated with an ascending salpingitis. Endometritis may occur with STDs or secondary to invasive surgical procedures (including dilation and curettage, abortion, insertion of an IUD, or hysterosalpingography) or parturition. It is more common after birth by cesarean section.

Endometritis that follows a septic abortion can rapidly lead to shock and death. Although the incidence of septic abortions has decreased, this complication can also occur after legal abortion. Toxic shock from *Clostridium sordellii* has also been reported after medical abortion induced by mifepristone and misoprostol. It is important for physicians to be aware of the possibility because early symptoms of toxic shock (vomiting, diarrhea, and abdominal cramping) are similar to the side effects of misoprostol. Tachycardia, hypotension, and absence of fever are distinctive features of *C. sordelii* infection (Fischer et al., 2005).

Tumors

The most common type of tumor of the uterine corpus is the benign leiomyoma, commonly but incorrectly termed a "fibroid." These tumors can grow to be extremely large and may cause symptoms through impingement on other pelvic structures. The differential diagnosis includes (a) pregnancy, (b) ovarian tumor, (c) a redundant or distended cecum filled with feces, (d) a redundant sigmoid, (e) an appendiceal abscess, (f) diverticulitis, (g) carcinoma of the sigmoid colon, and (h) endometrial carcinoma.

Endometrial cancer may not cause any abnormalities detectable on pelvic examination. Vaginal cytologies occasionally pick up a case but they have a high incidence of false negatives. Thus, early

diagnosis of endometrial cancer depends on aggressive evaluation of all postmenopausal bleeding (at least if it occurs at unexpected times or in the absence of estrogen/progestogen supplementation) or of recurrent dysfunctional bleeding. With the availability of pipelles for nearly painless endometrial sampling, this may be done as a routine procedure even in postmenopausal women who do not experience bleeding.

Pregnancy

The physical signs of pregnancy are summarized in Table 22.2. With laboratory testing, pregnancy is usually diagnosed before the uterus is significantly enlarged on physical examination. Home tests may be positive at the time of the first missed menstrual period.

The presence of the Piskacek sign has been said to be reliable for identifying the placental site and, if unequivocal, to nearly preclude the existence of a tubal pregnancy (Munsick, 1985). However, an inexperienced practitioner could be falsely reassured, and mistakes could be life threatening (see the section on "Ruptured Ectopic Pregnancy" below). If a tubal pregnancy is suspected, do not rely on the physical examination. Serial measurements of human chorionic gonadotropin (HCG) or pelvic sonography are indicated.

The assessment of the progress of an ongoing pregnancy is beyond the scope of this text.

Complications of Abortion

Legal as well as illegal induced abortions may result in perforation of the uterus, with infection (*vide supra*), hemorrhage, and shock. A missed or incomplete abortion, whether natural or induced, may be the cause of persistent bleeding and infection. Presentation after an abortion may be delayed, and the history may not be spontaneously offered, especially if an adolescent has sought abortion without the knowledge of her parents. The occurrence of such complications is widely believed to be rare, but ascertainment may be incomplete. Physicians caring for young women need to be sensitive and aware of these possibilities.

The Adnexae

The mature ovaries are about 4 cm in length, 2 cm in width, and 8 mm in thickness (or about the size of the distal half of your little finger). Normal ovaries are impalpable in 13% of premenopausal women and 70% of postmenopausal women (Granberg and Wikland, 1988). An adnexal mass that persists for longer than 6 weeks or is larger than 6 cm needs evaluation (Carr and Wilson, 1994).

Cysts of the Ovary

A cyst of 6 cm or less could be a follicle cyst or a corpus luteum cyst. The former often disappears after the next menstrual period. The corpus luteum cyst, if it ruptures, could result in all the signs and symptoms of intraperitoneal bleeding and could even require surgery. Torsion of an ovarian cyst could present as a surgical abdomen.

Ovarian cysts of large size may be associated with hydatidiform mole, chorioadenoma destruens, or choriocarcinoma. In the Stein–Leventhal syndrome, the polycystic ovaries may sometimes be larger than the uterus. Polycystic renal disease may be associated with cysts in the ovary as well as other locations such as the broad ligament, the uterus, the bladder, the pancreas, and the thyroid. Ovarian enlargement may result from an endometrioma.

False Positives

Midline "tumors" that have occasionally simulated an ovarian cyst include a distended urinary bladder and the pregnant uterus.

If an ovarian cyst becomes very large, it must be distinguished from ascites as follows:

1. The differentiation might be made by percussion. Ascites displace the small intestine centrally, producing a tympanitic percussion note in midabdomen and dullness in the flanks. With an ovarian cyst, the intestine is pushed laterally so that there is midabdominal dullness and lateral tympany. (Be sure that the bladder is empty before performing this test.)
2. An ovarian cyst never produces a fluid wave.
3. With extremely large cysts, the Blaxland method may be used: Place a flat ruler on the abdomen just above the level of the anterior superior iliac spines, and press firmly backward. If the swelling is caused by a cyst, the pulsations of the aorta are transmitted to the fingers and can be demonstrated by the ruler (Clain, 1973). Ascites will not produce this effect.

Tumors of the Ovary

Most ovarian neoplasms are lateral or posterior to the uterus and so must be sought both bimanually and on rectovaginal examination. Unfortunately, about 72% of cancers have disseminated before the diagnosis is made.

The differential diagnosis of an ovarian mass includes the following: a low-lying distended cecum, a redundant sigmoid colon, appendiceal abscess, impacted feces in the rectosigmoid, diverticulitis, carcinoma of the sigmoid, pedunculated leiomyoma, desmoid tumor, urachal cyst, or retroperitoneal neoplasm or abscess. A hematoma of the rectus muscle, which may occur without history of trauma in anticoagulated patients, can be distinguished by its superficial location, demonstrated by voluntarily tensing the abdominal muscles. An ectopic pelvic kidney deserves special note.

About 25% of ovarian malignancies are accompanied by ascites at the time of discovery. Rarely, benign ovarian fibromas are associated with nonmalignant ascites and right pleural effusions (Meigs syndrome), which resolve with removal of the tumor (Kistner, 1986). Other benign ovarian cysts, teratomas, or even leiomyomas of the uterus may rarely be associated with ascites and hydrothorax (pseudo-Meigs syndrome). These conditions may also be associated with elevated levels of CA-125 (Domingo et al., 1998).

The Oviducts (Fallopian Tubes)

The oviducts are generally not palpable. However, when involved with PID, they may be felt as rubbery, cordlike structures, which may eventually become fixed in the posterior cul-de-sac or elsewhere. They may also present as a soft hydrosalpinx, which must be differentiated from an ovarian cyst. The mass of a tubo-ovarian abscess may be felt either anterior or posterior to the uterus. If a previously palpable mass suddenly disappears in the setting of a

hard, tender abdomen and signs of sepsis, one may be dealing with a ruptured tubo-ovarian abscess, a potential cause of death.

Pelvic tuberculosis, usually of the oviduct, is found in about 10% of women with the pulmonary disease (Kistner, 1986). A significant fraction of women with pelvic tuberculosis have no history of tuberculosis infection and present with a normal chest radiograph (Ryan et al., 1995). At first, the pelvic examination is completely normal. Later, slight thickening of the tubes and tubo-ovarian masses may occur. Finally, ascites may develop because of peritoneal involvement.

Synthesis

Ruptured Tubal or Ectopic Pregnancy

In the event of acute abdominal pain occurring in a woman who *could* be pregnant, one must consider ectopic pregnancy, which is responsible for 2% to 3% of all obstetric deaths. This diagnosis is treacherous because the physical findings are highly variable. In the past, a pregnancy test was often negative. Modern tests should be positive, but the physician has to remember to order one.

If there has been a leakage of blood, manipulation of the cervix may cause severe pain. The cul-de-sac may have a feeling of fullness caused by liquid blood, and culdocentesis may yield nonclotting blood, or there might even be a mass if the blood has clotted. The Cullen sign (Turner sign) (see Chapter 20) is quite rare (Smith and Wright, 1935).

Endometriosis

Endometriosis is defined as the presence of functioning endometrium outside of its normal situation. On physical examination, check for fixed ovarian masses, nodularity in the rectovaginal septum, and induration in the cul-de-sac. Among other areas affected are the lower genital tract (cervix, vulva, and vagina), pelvic peritoneum, umbilicus, and laparotomy scars. Endometriosis may be the cause of severe and recalcitrant dysmenorrhea.

Overview on Caring for Women

The epigram to this chapter expresses the view of far too many physicians who will never have a good understanding either of their patients or of the anatomy of melancholy. The "members of generation" are never impertinent to the physician's purpose as they have to do with the propagation of life itself, nor are the genitalia the only locus of difference between the two sexes. Sexual dimorphism exists, to a degree we are only now beginning to understand, in all parts of the body, including the heart and the brain, affecting to one degree or another the diagnosis and treatment of all illnesses.

This chapter has focused narrowly on the examination for sources of pathology, which all too often remain hidden because they are not even sought. However, technical skill and knowledge of anatomy and physiology are only the beginning: a necessary but by no means sufficient key to treating the patient as a human being, not just a collection of parts used for utilitarian or recreational purposes, relevant to the physician as cost centers, profit centers, or codes for an insurance form.

The physician must begin by always treating the patient's hidden parts, as well as the patient's private feelings and aspirations, with the utmost respect.

An Epilogue on "Pelvic Deferred,..."

In the following story, one of the central figures was a very fine observer who told the story about herself at a time when our paths were about to part.

A patient was admitted to the woman's medical floor at a prestigious hospital located in a cosmopolitan city on the West Coast. The admitting diagnosis was fever of unknown origin, which remained the diagnosis for 48 hours. At that time, the resident reviewed the chart with the intern and asked what the pelvic examination showed. The intern replied that she had not done a pelvic examination. My informant, who was then the resident, told the intern to do it immediately because it was part of the workup for fever of unknown origin.

Two days later, while reviewing the chart, the intern was again asked about the results of the pelvic, and again responded that she had not done the pelvic examination. The resident pointed out the various diagnoses that could cause the fever in this patient, which would be manifest in the pelvic examination, and again instructed her intern to do the pelvic.

The next day, the pelvic still had not been done, so the resident instructed her intern to do it instantly. The intern returned a few minutes later announcing that the patient refused the examination. At this point, the resident did what she should have done at the beginning. She went to the patient herself and announced that she, the resident, was going to perform the long-overdue pelvic examination. "But you *can't* perform an internal pelvic examination on me," the patient retorted.

"And why not?" asked the resident.

"Because," said the patient, "I'm a man."

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CHAPTER 23

The Rectum

They say man has succeeded where the animals fail because of the clever use of his hands, yet when compared to the hands, the sphincter ani is far superior. If you place into your cupped hands a mixture of fluid, solid and gas and then through an opening at the bottom, try to let only the gas escape, you will fail. Yet the sphincter ani can do it. The sphincter apparently can differentiate between solid, fluid and gas. It apparently can tell whether its owner is alone or with someone, whether standing up or sitting down, whether its owner has his pants on or off. No other muscle in the body is such a protector of the dignity of man, yet so ready to come to his relief. A muscle like this is worth protecting.

—Walter C. Bornemeier, 1960

Points to Remember:

- Explain the reason for the rectal examination to the patient, and provide him with tissue and privacy afterward.
- The rectal examination is also part of the pelvic examination and of the neurologic examination.
- Check the perianal skin, the sphincter tone, all four quadrants in the rectum, and the prostate in men. Have the patient perform a Valsalva maneuver at the end of the examination so you can check the farthermost reachable parts for polyps, masses, or mucosal changes. Also look at the stool and check for occult blood.
- "If you don't put your finger in it, you'll put your foot in it" (old medical school aphorism).

Preparing the Student

Before performing a rectal examination of the patient, you should have acquired some minimum physical skills that will permit you to conduct your examination causing as little discomfort and pain as possible. In bygone days, it was expected that all the medical students would have performed rectal examinations on each other before being set loose on patients. The type of diligent preceptorship requisite to such an activity is now as rare as a xebec.

Similarly, medical schools previously had a required proctology rotation. Among other educational opportunities, this included the chance to perform (with the patient's prior permission) a rectal examination on an anesthetized patient under the direct supervision of the patient's personal proctologist who was about to perform surgery.

There are excellent mannequins that will permit the student to gain some initial experience in inserting a lubricated gloved finger through a sphincter and palpating a variety of prostatic prostheses. If your school does not have such a mannequin, volunteers should be solicited from your Curriculum Committee.

Preparing the Patient for Examination

A Method

In the woman, the rectal examination is generally performed as part of the pelvic examination (see Chapter 22). However, in cases in which the pelvic examination has been deferred, the rectal examination can still be done by the method used for the man.

Positioning the Patient

The examination is often performed with the patient standing with his legs spread a few feet apart, leaning forward, his chest resting on the examining table. It is usually more dignified if the patient is lying down, as described below (assuming that a pelvic examination is not being done).

The bed-bound patient can be examined in one of two modified Sims positions, the two differing depending on whether the leg is extended or flexed: The patient may be placed in the left lateral decubitus position, as for a lumbar puncture, with the knees and hips flexed, the trunk flexed forward, and the arms holding the hips and knees in maximum flexion. The second position would be obtained by having the lower (left) leg fully extended at the knee and, more importantly, at the hip. This actually rolls the patient another 45 degrees toward the prone position. Which position is optimum depends on the given patient's skeletal mobility and/or the obscuring quality of the buttocks.

If the patient is in an immovable supine position, the hips can be flexed, the knees flexed (passively, if need be, and held by an assistant), and the anus thus exposed to the examiner. Although one can do a rectal examination and even obtain stool samples from a patient held in this position, one may not always be completely confident about what one is palpating.

Protecting the Patient's Dignity

Hand the patient some tissue at this time to hold for later use at the end of the examination and say. "I am going to use some lubricant to make the examination more comfortable for you. I will tell you when I'm done." (This last statement is made as a part of physicianhood. The patient will know very well when you are done.)

You can also hand the patient the tissue at the end of the examination, but some doctors become so busy with the guaiac test that they forget to do so. Besides, handing the patient the tissue

in the beginning shows the patient that you are sensitive to and anticipate his feelings. Having him hold the tissue makes him a more active participant and less acted upon, a matter that could become exquisitely important in light of the psychodynamics of some male patients.

Dr Douglas Lindsey of Arizona instructs the students to do the wiping (although this does not preclude handing the patient some tissue also) because they are wearing gloves and can discreetly dispose of the tissue. If you do this, tell the patient that you are cleaning off the lubricant. Then ask him to get dressed while you run a test for occult blood. Leave the room, being sure that a box of tissues and a covered wastebasket are conveniently within his reach. Before returning, allow the patient sufficient time to restore his dignity and wash his hands if he likes.

Do not forget to explain to the patient why he is being subjected to this examination in the first place! ("I'm checking for cancer or internal bleeding," for example.) In a survey conducted at the University of Minnesota, one third of patients said the internal medicine resident did not explain the reason for the rectal examination, and 41% of those who preferred to be offered tissue said they received some other type of postexamination care (Wilt and Cutler, 1990).

Examination

1. Put your gloves on, spread the patient's cheeks, and examine for external hemorrhoids, tumors, condylomata, ulcers, fissures, excoriations, prolapsing internal hemorrhoids, or anything that you have never seen before. You will probably fail to see a fissure if you do not spread the cheeks and put a little bit of stretch on the anus.

   Dr Frank Iber of Illinois adds: You can gain a great deal of information from inspection prior to the rectal examination. If the person, with a little straining, can show you the margin between the skin and the mucosa, this will reveal external hemorrhoids and skin irritation. If he is unable to relax sufficiently to show you this margin, it may indicate pathology that can be encountered with the finger or anoscope.

   While performing this part of the examination, you might also want to check the patient for the anal wink (see Chapter 26). Although an absent anal wink is sometimes observed in the presence of a large fecal impaction, persistence after disimpaction suggests a neurologic impairment (Whitehead et al., 2000).

   If the anal sphincter gapes open on parting the buttocks or exerting traction on the anal canal, neurologic or anatomic injuries should be suspected.
2. Put a generous amount of lubricant on your gloved index finger and say, "I am going to put some lubricant on you now. It might feel cold."
3. Place the lubricant at the anal orifice. If the patient has asked whether this is going to hurt, you should say, "No, it will be uncomfortable but it shouldn't produce a pain in the sense of being a sharp sensation. If I do anything during the examination that makes you feel a sharpness, or a pain, be sure to tell me."

   If the patient has not raised this issue, at this point you should say, "This might feel a little uncomfortable," or "You'll feel a pressure." (Do not call it a "pain.") Depending on the individual patient, you might add, "But it shouldn't be painful." You want to encourage him to report any such sharp painful sensation because it is a clue to the presence of a mucosal tear, a prostatic inflammation, or a rectal abscess. The patient may also be forewarned that there might be a false sensation of being about to have a bowel movement.
4. At this point, it is assumed that you have practiced the rectal examination on a mannequin or an anesthetized patient. Accordingly, you may have become inappropriately cavalier about the rectal sphincter. Gently press the tip of your index finger through the center of the sphincter so that the entire circumference of your finger is coated with lubricant. Note the anal sphincter tone.
5. Insert the examining finger as far as possible and prepare to sweep the four quadrants searching for abnormalities (*vide infra*).
6. Finally, ask the patient to perform a Valsalva maneuver ("bear down as if having a bowel movement") so that you can make a final check of the lumen, feeling for polyps and other masses, and the farthermost rectal mucosa. Say "we're almost done" or words to that effect.
7. Withdraw the examining finger and inspect it for stool. Note its appearance, and place a smear on a slide for occult blood testing or sometimes for other tests such as stool fat stains (see Chapter 28). If you wipe off the lubricant, dispose of the tissue paper inside the glove, which you should turn inside out as you remove it.

Findings

Inspection

Fissures or Fistulae

The presence of a perianal fistula and/or fissure suggests that a patient with inflammatory bowel disease has Crohn regional enteritis rather than chronic ulcerative colitis.

Pilonidal Sinus

Although often misdiagnosed as a "fistula in ano," a pilonidal sinus is actually located some distance away from the anus, in the midline near the base of the coccyx. Purulent fluid may be expressed by pressure over the sacrum (Clain, 1973).

Skin Lesions

Pruritus ani, with erythema and lichenification of the perianal skin, may result from a variety of causes, such as sensitivity to various foods, condiments, coffee, drugs, irritants in toilet tissue and undergarments, and topical preparations used to treat itching. A symmetric pink discoloration is said to be characteristic for sensitivity to dairy proteins (Friend, 1987). Parasitic infestations (most commonly pinworms) and fungal infections (such as *Candida* or tinea; Fig. 23-1) are also a possibility. Be attentive for evidence of sexually transmitted diseases such as chancre (see Table 21.1), which may present in the perianal region rather than on the genitalia, especially in homosexual

Figure 23-1 A classical perianal tinea infection; KOH prep was positive. (Photograph courtesy of Dr Chester Danehower, with permission.)

men. Genital warts (condyloma acuminata) may occur perianally and also inside the anal canal. These may be sexually transmitted, but autoinoculation and fomite transmission also occur (Bays and Chadwick, 1993). Ruling out fomite transmission is very difficult because the incubation period may be years long (Paul, 1990).

Increased pigmentation around the anus, although reported after chronic sexual abuse, is a common finding in nonabused children. Bruises in the anal area can raise suspicion of possible sexual abuse. Bruising confused with sexual abuse has been reported in the Ehlers–Danlos syndrome, hypersensitivity vasculitis, purpura fulminans, and meningitis with disseminated intravascular coagulation. Other dermatologic conditions that can cause pain, bleeding, fissures, and skin changes in the anogenital region, which must be differentiated from signs of sexual abuse, include lichen sclerosus, lichen planus, seborrheic dermatitis, atopic dermatitis, contact dermatitis, lichen simplex chronicus, and psoriasis (Bays and Jenny, 1990). See Chapter 7 for a further discussion of some of these conditions as well as Mongolian spots and phytodermatitis.

Signs of Sexual Abuse

Many of the findings attributed to sexual abuse have been found on careful study to be surprisingly common in normal, nonabused children who were examined and photographed in the knee–chest position. Venous engorgement was seen in about three fourths of the children who remained in that position for 4 minutes or longer, although it was uncommon (seen in only 7%) at the beginning of the examination. Anal dilation, especially if stool was present in the ampulla, was common, and intermittent opening and closing of the sphincters was not unusual. Findings that were uncommon in nonabused children included the following: skin tags and scars outside the midline (0% and 1%); anal dilation greater than 20 mm without the presence of stool in the ampulla (1.2%); irregularity of the completely dilated anal orifice (3%); and prominence of the anal verge (3%). None of the 267 subjects, aged 2 months to 11 years, had abrasions, hematomas, fissures, or hemorrhoids (McCann et al., 1989).

A Self-study

Assume that 1% of 8-year-olds in a screened population of 1,000 have actually been sodomized. Assume that irregularity of the anal orifice is 100% sensitive for the presence of such abuse. Given the figures above for nonabused children, calculate the predictive value of a positive test. Then consider a population in which the probability of abuse is 50%. What is the predictive value of a positive test in that population? (Answers are in Appendix 23.1.)

Given the unreliability of many of the physical findings, and the fact that more than 70% of cases will have no physical findings at all if the examination is long delayed, the most important evidence for sodomy is the history of pain during penetration and, more importantly, pain on defecation soon afterward. It is often the soiling resulting from secondary constipation, as the child holds back defecation, that brings the case to attention. A full bowel history will disclose that there has been a change or that, alternately, the perianal redness results from chronic constipation and passage of hard stool. As in so many other areas, "the failure to take a full history is probably the greatest pitfall that exists" (Paul, 1990).

Perianal Ecchymosis

A ringlike perianal ecchymosis (the Bryant sign) may occur with intraperitoneal bleeding.

Palpation

Sphincter Tone

One of two abnormalities may be found in the sphincter tone. A pathologic tenderness and resistance to a properly performed insertion indicates a local abnormality. Insufficient resistance of the sphincter indicates a neurologic abnormality, frequent practice of receptive anal intercourse, or the residuum of a mechanical problem (e.g., a laceration occurring during childbirth). (The ability of the patient to squeeze the clinician's finger with the rectal sphincter is an excellent alternate test of spinal cord integrity—also see the bulbocavernosus reflex in Chapter 26.)

Pelvic Floor Dyssynergia

Up to 50% of patients with functional fecal incontinence may have pelvic floor dyssynergia, a contraction of, or failure to relax the pelvic floor muscles during attempts to defecate. During the digital rectal examination, when the patient is asked to strain, check for paradoxical contraction of the external sphincter and/or the puborectalis, or poor descent of the perineum (Whitehead et al., 2000).

Internal Findings

Anteriorly, everyone should be able to palpate the prostate (*vide infra*). With a little more experience, one can also detect a distended bladder as well as seminal vehicles that have enlarged secondary to disease. The Cowper bulbourethral glands, situated inferior to the prostate, are usually palpable only if inflamed. In women, note enlargement and displacement of the uterus, and—in the pouch of Douglas—swellings, carcinomatosis, or the bulging of a pelvic abscess.

Laterally to the patient's right, one can elicit tenderness from an inflamed and swollen appendix. This is especially important if the patient has a retrocecal appendix, which may not produce the expected findings on abdominal examination. Laterally to the

patient's left, one might find tenderness due to diverticulitis or abscess.

Posteriorly, one can palpate the pyriformis muscle and an occasional tumor in the presacral area. One may demonstrate tenderness in the sacrococcygeal joint. An aneurysm of the internal iliac artery may be felt as a pulsating mass.

Higher in the canal, one can find a stricture due to cancer or fibrosis, rarely postobstructive dilation of the canal, and very rarely the apex of an intussusception. The feeling that there are multiple small adenomas in the rectal mucosa should suggest that one is palpating the pseudopolyps of chronic ulcerative colitis.

Tumors may be found in any of the above locations.

The presence of impacted stool (which occurs around the obstructing feces) may explain diarrhea, abdominal discomfort, and even difficulty with voiding.

The Prostate

Size

The size of the prostate in the normal young man and in the senior citizen with benign prostatic hypertrophy is best learned from the mannequin in the teaching lab. For those without such a tool, the young man's prostate is roughly the size of a walnut, and the older man's enlarged prostate is the size of a lemon. Given the difficulties in assessing the size of a globular object from palpation of a restricted area of its surface, one should probably just say "normal" or "enlarged," after achieving sufficient experience.

Consistency

A Teaching Trick. One can teach students to describe the consistency of the palpated prostate gland by using one's own flexed thumb as a model. "Hard" means like any bony prominence. "Indurated" is like the extensor pollices as they are stretched taut over diaphyseal bone. "Normal" is like the tensed thenar eminence. "Boggy" is like the relaxed thenar eminence (in imitation of acute prostatitis). It is important to keep checking your descriptions against your own thumb because with fatigue and distraction, you may be changing your usage of the last two terms.

"Boggy" is a word that should probably be eliminated from the terminology of clinical examination, as it is now used only as a shibboleth with prostatitis. It is true that a peat bog is soft and that some *acutely* inflamed glands do seem soft like a peat bog. This impression is partly explained by cysts or abscesses and partly by the fact that the gland is so tender that one cannot get a good feel of it without causing the patient to move away. However, in some books, "boggy" refers to chronic prostatitis, incorrectly, I believe, as the chronic form of prostatitis is more likely to be "indurated," sometimes with sufficient fibrosis so that it is "hard" enough to raise a suspicion of neoplasia.

False Positives. Wiener and Nathanson (see Chapter 29) warn that elderly men with atrophic prostate glands may have their bony symphysis pubis palpated and a "stony hard" gland misidentified.

Prostatic Nodules

Prostatic nodules are a sign of neoplasm and are an indication for biopsy. Oddly enough, in some series, only about 50% of prostate nodules actually turn out to be neoplasm, the rest being nodular hyperplasia. If the nodular induration is secondary to tuberculosis, one or both seminal vesicles and the vas deferens are also involved in most cases (Clain, 1973).

Whereas we were formerly taught to feel for a bony hard spot in the prostate, more recent thinking points out that a bony hard spot in the prostate is a relatively late finding. Even a spot of induration should be noted and biopsied (Chodak and Shoenberg, 1985).

A Self-study

Considering that a lymphoma metastatic to the prostate can also produce a hard prostate, what would happen to the specificity of the test (hard prostate as a test for prostatic carcinoma) in an oncology clinic and to the predictive value of a positive test? (Appendix 23.2.)

The rectal examination was previously the most sensitive test for detecting carcinoma of the prostate, but the sensitivity is only 69% and the specificity is 89% (Guinan et al., 1980). The prostate-specific antigen (PSA) has displaced the rectal examination as the most sensitive test for carcinoma of the prostate; however, it has by no means reduced the importance of performing the rectal examination.

The PSA is by no means perfect; it can be elevated in benign states, including prostatic hyperplasia, benign prostatitis, and prostatic infarction. It is far more sensitive than the acid phosphatase, the test used in bygone days, which usually indicates extraprostatic disease.

The Three-glass Test. This special test for localizing a urinary tract infection is described in Chapter 28.

Alleged Adverse Effects of the Rectal Examination

False Positives

The rectal examination does not cause false-positive elevations of the PSA (Brawer et al., 1988) in patients with benign prostatic enlargement. It is therefore not necessary to draw the blood prior to rectal examination.

Myocardial Infarction

Students may have been admonished not to perform a rectal examination in a patient suffering a myocardial infarction because of the possibility of precipitating a fatal arrhythmia by stimulating a reflex. This is not exactly an old wives' tale. There have been isolated case reports of adverse consequences occurring in conjunction with a rectal examination. In the case of a woman with complete heart block, gentle rectal stimulation reliably induced a Stokes–Adams attack. Eight episodes of syncope or marked faintness occurred in the course of examinations of 2,500 servicemen in which moderate pressure was exerted on the prostate for 2 to 8 seconds. The Valsalva maneuver, which may accompany a rectal examination, may induce or intensify electrocardiographic abnormalities, particularly when accompanied by hyperventilation (Lee and Herbert, 1997). However, none of these reports examine the performance of a rectal examination in patients with a myocardial infarction.

In a series of 86 patients with documented acute myocardial infarction, a *gentle* rectal examination was performed within 24 hours of admission and not found to produce a single example

Figure 23-2 Anoscope with attachable light source. (Courtesy of Dr Devra Marcus, Washington, DC, with permission.)

of death, arrhythmia, or even angina. The unsuspected findings of occult blood, prostatic enlargement, and voluminous hard stool were encountered rather frequently. Thus, the value of rectal examination in planning anticoagulant therapy and bowel and bladder care outweighs the hypothetical risk (Earnest and Fletcher, 1969). These results were confirmed in another prospective study of 40 patients with acute myocardial infarction within 8 hours of the onset of chest pain. No appreciable changes occurred in blood pressure, heart rate, rhythm, or electrocardiogram during or after the rectal examination (Lee and Herbert, 1997).

The pre-1968 medical school aphorism still applies: "If you don't put your finger in it, you'll put your foot in it."

Special Maneuver: Anoscopy

A look inside the anus with a disposable anoscope (shown in Fig. 23-2), a procedure readily accomplished in a medical office, can show the state of the mucosa and provide samples of exudate, if any, for microscopic examination. Also check for hemorrhoids, which occasionally may be identified as the source of acute bleeding (but do not omit to check for more proximal disease, especially if the hemorrhoid is not seen to be actively bleeding).

The rigid anoscope is preferred to the flexible sigmoidoscope to determine whether fissures, inflammation, or mechanical obstruction are contributing to fecal soiling (Whitehead et al., 2000).

Screening for Colorectal Cancer

Patients should be instructed in the need for periodic screening for colorectal cancer, especially if they have reached the age of 50 or have other risk factors. Providing a kit for home collection of specimens for fecal occult blood testing, together with dietary instructions, is one approach. In a European study, which had lower costs for colonoscopy and other follow-up tests than those that are prevalent in the US, the cost of identifying one colorectal adenoma was about $1,400, and one colon cancer about $5,500, with fecal occult blood testing as the screen (Manus et al., 1996). In 2004, the American Cancer Society recommended annual occult blood testing, plus flexible sigmoidoscopy every 5 years, beginning at age 50. The disadvantage of this approach is that cancers bleed only intermittently, and premalignant polyps beyond the reach of the sigmoidoscope may not bleed at all. Some recommend colonoscopy every 10 years for everyone over the age of 50. Better molecular tests, virtual colonoscopy, or other developments may lead to better screening. The key point to be made here is the need to be aware of the high prevalence of colon cancer and the effectiveness of early detection, and to implement the best available method for your practice.

The time of the rectal examination could be a good time to discuss screening with the patient. It could also remind you to double-check for family history of colon cancer or a personal history of inflammatory bowel disease or polyps.

Appendix 23.1

Answer to Self-study (Signs of Sexual Abuse)

If the prior probability of abuse is 1%, and of nonabuse 99%, then the true positives (TP) = 10, the false positives (FP) = (0.03)(990) = 29.7, and the predictive value of a positive test is about 25%. If the prior probability of abuse is 50%, however, then TP = 500, FP = (0.03)(500) = 15, and the predictive value of a positive test = 97%.

Appendix 23.2

Answer to Self-study (Prostatic Nodules)

The false positives for prostatic cancer would increase because of the increasing proportion of cases of lymphoma. Because the specificity is equal to the true negative divided by the sum of the true negatives and false positives, the specificity in this instance would decrease. Also, the predictive value of a positive test (true positives over the sum of the true positives and false positives) would decrease.

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CHAPTER

24

The Extremities

For more than twenty years I have amused my compulsory leisure with collecting these curious physical signatures in this town. At my house I have hundreds and hundreds of them .... I have the finger-prints of the court, the sheriff, and every member of the jury. There is hardly a person in this room...whose natal signature I cannot produce, and not one of them can so disguise himself that I cannot pick him out from a multitude of his fellow-creatures and unerringly identify him by his hands. And if he and I should live to be a hundred I could still do it.

—MARK TWAIN, *PUDD'NHEAD WILSON*

POINTS TO REMEMBER:

- Examination of the hand reveals signs of immunologic, congenital, dermatologic, cardiac, or other conditions.
- The diagnosis of connective tissue diseases involves weighing a combination of historical, physical, and laboratory findings.

This chapter is a compendium of findings on examination of the extremities that indicate certain systemic conditions. A detailed examination of the neuromusculoskeletal system, including the synovial joints, will be given in Chapters 25 and 26. Other manifestations of conditions covered in this chapter may be found in Chapters 7, 17, 18, and 19.

Upper Extremities

Various Findings in Rheumatic Diseases

Nodules

The extensor surfaces of the upper extremities are the best places to find rheumatoid nodules, which can be found in about 28% of patients with rheumatoid arthritis. About 90% of such patients have nodules on the elbows, 14% on the fingers, 13% on the knees, 7% on the ankles, and 5% on the occiput. Rheumatoid nodules are not diagnostic for rheumatoid arthritis, but in patients with rheumatoid arthritis, the presence of nodules predicts a 90% chance of having rheumatoid factor (Kaye et al., 1984).

Nodules also occur in about 9% of patients with rheumatic fever. About 80% of such patients have nodules on the elbow, 19% on the fingers, 48% on the knees, 20% on the ankles, and 20% on the occiput (Benedek, 1984).

Table 24.1 shows diseases associated with subcutaneous nodules similar to those found in rheumatoid arthritis. Those in boldfaced letters have the best track record for fooling the clinician. Fortunately, most of these diseases have either decreased somewhat in prevalence (rheumatic fever, tophaceous gout, gummatous syphilis) or the diagnoses can be made on other grounds.

A Self-study

In your practice, you see 95 patients with rheumatoid arthritis for every five patients with rheumatic fever. What, then, is the likelihood (in your practice) that a patient with an occipital nodule has one or the other of the two diseases? The answer is in Appendix 24.1.

The Hand in Various Arthritides and Connective Tissue Diseases

Rheumatoid Arthritis

Rheumatoid arthritis can be diagnosed in some cases simply by inspecting the hand, even when no nodules are present. First, there may be interosseus atrophy, best noted by inspecting the dorsum of the hand in oblique lighting, but with practice, discernible in direct light. Weakness of the interossei results in inability to forcefully extend the interphalangeal joints, which is necessary for finger-flicking movements. Second, there is ulnar deviation of the hand and the fingers. The best fingers to check for ulnar deviation are the third and index fingers, as many normal older persons will appear to have mild ulnar deviation of the other fingers. In severe carpal rheumatoid arthritis, however, all the fingers show a clear ulnar deviation.

It is worth remembering that rheumatoid arthritis of the wrist tends to spare the radial side of the joint. In fact, a severe arthritis of the wrist that spares the ulnar side and vigorously attacks the radial side is likely to be osteoarthritis (degenerative joint disease). Also remember that classic rheumatoid arthritis never attacks the distal interphalangeal (DIP) joints.

Other manifestations of rheumatoid arthritis include (a) loss of grip strength; (b) limited flexion in one or more fingers due to nodular tenosynovitis (felt as a small movable nodule in the flexor tendon as you passively flex and extend the joint); (c) vasculitic lesions, which may herald serious systemic vasculitis (Weiss, 1984); and (d) Haygarth nodes (actually not nodes but fusiform synovial swellings of the proximal interphalangeal [PIP] joints).

Dr Gerry Rodnan of Pennsylvania made the diagnosis of rheumatoid arthritis by squeezing the metacarpal heads during a handshake (Rodnan et al., 1973). This can be quite painful for the patient. If you suspect this diagnosis, it is better not to shake hands but simply to ask what would happen if you were to squeeze the patient's hand.

The American College of Rheumatology criteria for the diagnosis of rheumatoid arthritis are given in Table 24.2. Although the criteria focus on joint manifestations, remember that rheumatoid arthritis is a systemic disease (see Chapter 10 for eye findings).

TABLE **24.1** *Diseases associated with subcutaneous nodules similar to those found in rheumatoid arthritis*[a]

Rheumatic and immunologic diseases
- **Rheumatic fever**
- **Systemic lupus erythematosus**
- **Tophaceous gout**
- Discoid lupus erythematosus
- Anarthritic rheumatoid syndrome
- Degenerative joint disease (Heberden nodes)
- Sarcoidosis
- Weber–Christian disease
- Agammaglobulinemia with polyarthritis
- Dermatologic disease
- **Granuloma annulare**
- Erythema elevatum diutinum
- Acrodermatitis chronic atrophicans
- Discoid lupus erythematosus
- Basal cell carcinoma
- Sebaceous cysts
- Metabolic diseases
- **Tuberous xanthomatosis (see Chapter 7)**
- Neoplastic diseases
- Multicentric reticulohistiocytosis
- Basal cell carcinoma
- Infectious diseases
- **Syphilis**
- Synovial tuberculosis
- Candidiasis
- Bejel
- Yaws
- Pinta
- Leprosy (Hansen disease)
- Miscellaneous conditions
- Ganglions of the hand or wrist
- Foreign body reactions
- Chemical irritations
- Delayed local reaction to tuberculin

[a]Conditions in bold face have fooled the clinician most consistently.
From Kaye BR, Kaye RL, Bobrove A. Rheumatoid nodules: Review of the spectrum of associated conditions and proposal of a new classification, with a report of four seronegative cases. *Am J Med.* 1984;76:279–292, with permission.

Generalized symptoms such as fatigue, weight loss, malaise, and depression are also common (Lee and Weinblatt, 2001).

Although the patient's and the doctor's attention may be focused on the peripheral joints, the cervical spine is affected early in the course of rheumatoid arthritis, even within the first two years (see Chapter 25). This is for some reason strongly correlated with involvement of the carpal and metacarpophalangeal (MCP) joints (K. Smith, *personal communication*, 2009) and with erosions in the bones of the hands and feet (Winfield et al., 1983).

TABLE **24.2** *Diagnostic criteria for rheumatoid arthritis*

Criterion	Definition
1. Morning stiffness	In/around joints, lasting at least 1 hour before maximal improvement
2. Arthritis of three or more joint areas	At least three areas simultaneously have had soft tissue swelling or fluid; the 14 possible areas are R/L PIP, MCP, wrist, elbow, knee, ankle, and MTP joints
3. Arthritis of the hand joints	At least one area swollen in the wrist, MCP, or PIP joint
4. Symmetric arthritis	Bilateral PIP, MCP, MTP without absolute symmetry acceptable
5. Rheumatoid nodules	Subcutaneous nodules over bony prominences, extensor surfaces, or in juxta-articular regions
6. Serum rheumatoid factor	By any method in which result has been positive in <5% of normal control subjects
7. Radiographic changes	PA hand/wrists X-ray with erosions or bony decalcification in or adjacent to involved joints

Four or more criteria needed to make diagnosis; must have 1–4 for at least 6 weeks.
PIP, proximal interphalangeal; MCP, metacarpophalangeal.
Source: From Mayeaux EJ Jr. *2000 Revised ARA Criteria for Classification of Rheumatoid Arthritis.* Intern-in-the-middle-of-the-night series. Shreveport, LA: Louisiana State University Health Sciences Center. Available at: http://lib-sh.lsumc.edu/fammed/intern/ra.html. Accessed: June 18, 2004, with permission.

Wasting of the forearm and hand muscles may result from compression of the anterior spinal artery at upper and mid cervical levels (Mathews, 1998).

Psoriatic Arthritis

This seronegative rheumatoid variant attacks the DIP joints. The diagnosis is suggested by the associated skin and nail changes (see Chapter 7). Psoriatic arthritis may be severely deforming, whereas osteoarthritis is not.

Osteoarthritis

This "degenerative," seronegative arthritis produces characteristic nodules of the DIP joints called *Heberden nodes*. These feel like two little dried split peas placed subcutaneously on the lateral and medial dorsal surface of the finger at the DIP. When they are present on the PIP joint, they are called *Bouchard nodes*. Osteoarthritis tends to spare the MCP joints.

Scleroderma

The American College of Rheumatology criteria for the diagnosis of progressive systemic sclerosis require the presence of

proximal scleroderma (skin tightness) or the presence of two of three other criteria. These criteria are

1. Sclerodactyly (*vide infra*);
2. Digital pitting scars;
3. Bibasilar pulmonary fibrosis.

Proximal is defined as above the wrists by the American College of Rheumatology, and above the elbows by various others. The criteria were designed for research and thus exclude individuals in whom the disease is not fully expressed. Scleroderma skin changes above the MCP or metatarsophalangeal (MTP) joints are 91% sensitive and 99.8% specific for definite scleroderma (Wigley, 2001).

Nail-fold capillary changes are described in Chapter 7.

Patients with sclerodactyly alone have some or all of the features of the CREST syndrome, and it has been argued that this syndrome should be called "limited scleroderma." The CREST syndrome includes calcinosis, the Raynaud phenomenon (see Chapter 18), esophageal dysmotility, sclerodactyly, and telangiectasia.

New criteria have been proposed for early diagnosis and classification on the basis of advances such as the identification of scleroderma (anticentromere) autoantibodies and other advances (LeRoy and Medsger, 2001). Disease manifestations are variable and complex. The use of a term such as "undifferentiated connective disease with features of scleroderma" has been suggested as a hedge against overdiagnosis and overly aggressive treatment (Wigley, 2001).

Systemic Lupus Erythematosus

Systemic lupus erythematosus (SLE) is a multisystem disease diagnosed by a combination of clinical and laboratory criteria. The American College of Rheumatology diagnostic criteria are given in Table 24.3. Always remember that diseases do not necessarily fit precisely into authoritatively defined pigeonholes. In particular, there are many more neurologic manifestations, both central and peripheral, that have been attributed to lupus. These include demyelinating disorders, chorea, Guillain–Barré syndrome, myasthenia gravis, and autonomic disorders (Ruiz-Irastorza et al., 2001).

TABLE **24.3** *Diagnostic criteria for systemic lupus erythematosus*

Criterion	Definition
1. Malar rash (see Fig. 9-9)	Fixed malar erythema, flat or raised, tending to spare the nasolabial folds
2. Discoid rash (see Fig. 7-10)	Erythematous raised patches with adherent keratotic scaling and follicular plugging
3. Photosensitivity	Skin rash as a result of unusual sensitivity to sunlight
4. Oral ulcers	Oral or nasopharyngeal ulceration, usually painless
5. Arthritis	Nonerosive arthritis involving peripheral joints, with tenderness, swelling, or effusion
6. Serositis	Pleuritis—convincing history of pleuritic chest pain or rub or evidence of pleural effusion OR pericarditis—documented by ECG, rub, or evidence of pericardial effusion
7. Renal disorder	Persistent proteinuria, >0.5 g/day or >3+ if quantification is not performed OR cellular casts—may be red cell, hemoglobin, granular, tubular, or mixed
8. Neurologic disorder	Seizures OR psychosis in the absence of offending drugs or known metabolic derangements (uremia, ketoacidosis, or electrolyte imbalance)
9. Hematologic disorder	Hemolytic anemia—with reticulocytosis OR leukopenia: <4,000 total at least twice OR lymphopenia: <1,500 at least twice times OR thrombocytopenia: <100,000 in absence of offending drugs
10. Immunologic disorders	Positive antiphospholipid antibody OR anti-DNA OR anti-SM OR false-positive serologic test for syphilis
11. Antinuclear antibody	Positive antinuclear antibody (ANA), at any point in time, and in the absence of known drugs to be associated with "drug-induced lupus" syndrome (see Table 24.4)

Diagnosis requires four or more manifestations present serially or simultaneously. Remember that these are simply "criteria." Always use your clinical judgment in evaluating a patient for potential lupus.
From Gill JM, Quisel AM, Rocca PV, et al. Diagnosis of systemic lupus erythematosus. *Am Fam Physician*. 2003;68: 2179–2186 and Callegari PE, Williams WV. Laboratory tests for rheumatic diseases: When are they useful? *Postgrad Med*. 1995;97(4):65–74, with permission.

TABLE **24.4** *Drugs associated with systemic lupus erythematosus*

Definite association
- Chlorpromazine
- Hydralazine
- Isoniazid
- Methyldopa
- Procainamide
- Quinidine

Possible association
- β blockers
- Atenolol, labetalol, timolol
- Captopril
- Carbamazepine
- Clonidine HCl
- Danazol
- Disopyramide
- Ethosuximide
- Gold compounds
- Griseofulvin
- Interferon alpha
- Leuprolide acetate
- Levodopa
- Lithium
- Lovastatin
- Mephenytoin
- Methyldopa
- Methysergide
- Minoxidil
- Nalidixic acid
- Nitrofurantoin
- Nonsteroidal anti-inflammatories
- Diclofenac, ibuprofen, sulindac
- Oral contraceptives
- Penicillamine
- Penicillin
- Phenelzine sulfate
- Phenytoin
- Prazosin
- Primidone
- Promethazine
- Propylthiouracil
- Psoralen
- Spironolactone
- Streptomycin
- Sulfasalazine
- Tetracycline
- Thioridazine
- Tolazamide
- Tolmetin
- Trimethadione

From Greenberg B, Michalska M. Systemic lupus erythematosus. *Postgrad Med.* 1999;106:213–223, with permission.

Almost all patients experience arthralgias and myalgias, and most develop intermittent arthritis. Pain is often out of proportion to physical findings. Characteristically, there is symmetric fusiform swelling of joints, most frequently the PIP and MCP joints and the wrists and knees. Diffuse puffiness of hands and feet, and tenosynovitis, may be seen. In contrast to rheumatoid arthritis, joint deformities are unusual, with only 10% of patients developing swan-neck deformities of the fingers and ulnar drift at MCP joints. Erosions are rare. Subcutaneous nodules occur.

A careful drug history is mandatory. Drugs that have been associated with SLE are listed in Table 24.4. The syndrome is rare except with procainamide (the most common offender) and hydralazine, and is probably related to genetically determined drug acetylation rates.

Gout

Tophi occur more frequently on the ears and feet, and when present on the hand (Fig. 24-1), though highly suggestive of gout, could be initially confused with a rheumatoid nodule. Definitive diagnosis is made by joint aspiration and demonstration of urate crystals (see Chapter 28). Presence of a tophus is 33% sensitive and 93% specific for gout.

Hemochromatosis

Patients with hemochromatosis are prone to a degenerative type of arthritis that can affect the hands and fingers as well as the joints of the lower extremities. The PIP joints of the middle and ring fingers may be affected, mimicking the Haygarth fusiform swelling of rheumatoid arthritis confined to those joints.

Self-test

See Figure 24-2 Legend.

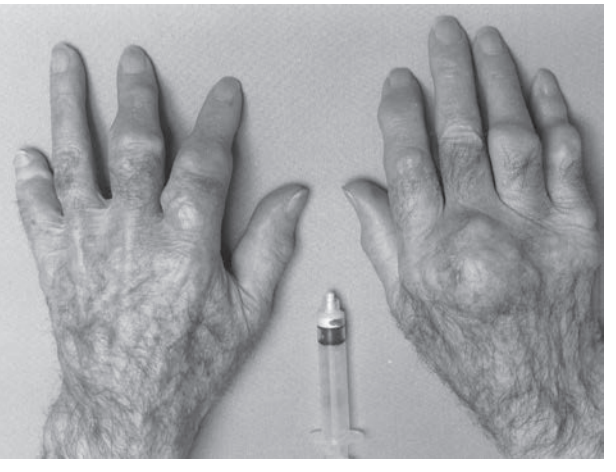
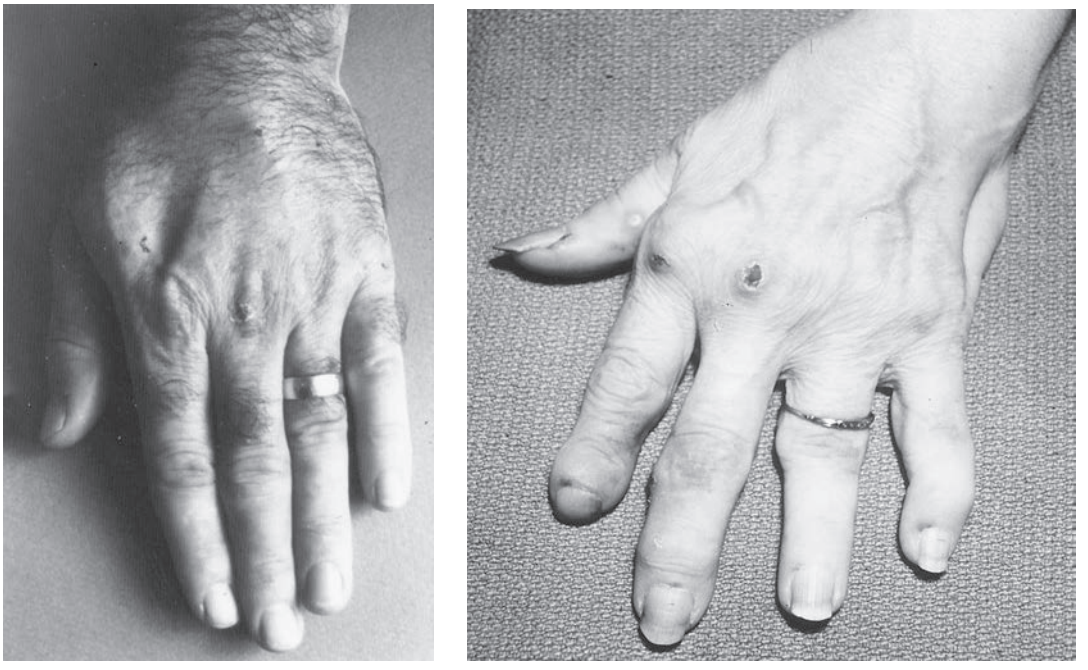


FIGURE 24-1 This phlegmatic patient accepted the diagnosis of "arthritis" for many years. No one seemed to realize that the development of these tophi was not an inevitable consequence of "arthritis." Aspiration of the joint by Dr Renee Ridzon of Massachusetts revealed the milk of urate shown in the syringe. Examination of the fluid by means of the improvised polarizing microscope and first-order compensator (see Chapter 28) revealed the pathognomonic urate crystals. (Courtesy of Dr Renee Ridzon, Massachusetts.)



A B

Figure 24-2 **A, B:** Self-test: One hand belongs to a patient with rheumatoid arthritis and one to a patient with porphyria cutanea tarda. Identify the diagnosis and then the skin lesions. Skin lesions must always be considered in the context in which they occur. Neither of these diagnoses could easily be made from the skin lesions alone. Therefore, look for interosseus muscle atrophy and slight ulnar deviation, the signs of rheumatoid arthritis but not porphyria (see Appendix 24.2 for the answer).

Bony Anomalies

Short Fourth Metacarpal

One can diagnose a short fourth metacarpal without taking a radiograph by having the patient make a list and noticing that the fourth knuckle is dimpled inward. Shortening of this bone is seen in pseudohypoparathyroidism, pseudopseudohypoparathyroidism, gonadal dysgenesis (Turner syndrome), and in 10% of healthy subjects (Levin and Kupperman, 1964; Slater, 1970).

The hypothesis that pseudohypoparathyroidism resulted from end-organ resistance to a circulating hormone was first proposed by the Boston endocrinologist Fuller Albright. This possibility, previously unknown as a mechanism for human disease but subsequently confirmed, was suggested to him by analogy with the Sebright bantam rooster, which fails to develop secondary sex characteristics owing to end-organ resistance to circulating male sex hormones. A careless typesetter changed the Sebright bantam syndrome to the "Seabright-Bantam" syndrome, allowing Drs Seabright and Bantam to join Dr Jod (see Chapter 14) in the pantheon of eponymously immortalized, albeit nonexistent, endocrinologists.

Metacarpal Index

By palpation, one can estimate the metacarpal length-to-width ratio (metacarpal index) as a method of quantitating the elongation of the metacarpal bones in Marfan syndrome (also see section on "Arachnodactyly" below). The independent covariable is posteroanterior hand films taken with the hands flat against the plate, which are used for measurement of the second through fifth metacarpals. The ratio of the length of the bone divided by the width (at the midpoint of the length) is used to generate an average, whose upper limit of normal is 8.8 for men and 9.4 for women (Eldridge, 1964). This ratio distinguished the patients with Marfan syndrome from those without it.

Acromegaly

Acral enlargement, the literal translation of "acromegaly," involving the hand, foot, and head, occurs in 98% of cases of this disease. Actually, the hand develops a characteristic appearance that is easy to recognize once seen. This is called the "spade hand" because the hand vaguely resembles the garden implement (Fig. 24-3). The diagnosis of acral enlargement may also be based on the history of an increase in glove, ring, shoe, and/or hat size (Braunstein, 1986).

The feet also enlarge in acromegaly, and the heel pad thickens, the latter originally being demonstrated radiographically.

The Palms

Skin

Lesions of the palmar skin may be divided into dermatologic conditions and those that are part of a systemic medical illness.

Dermatologic Conditions

Dermatologic conditions include ichthyosis vulgaris, X-linked ichthyosis, recalcitrant pustules, hand-foot-and-mouth disease, lichen planus, pompholyx, some forms of psoriasis, the dermatophytoses (including tinea), and a variety of contact dermatitides.

Conditions Related to Systemic Illness

Conditions related to systemic illness include those that are part of a generalized eruption—secondary syphilis (see Fig. 21-4),

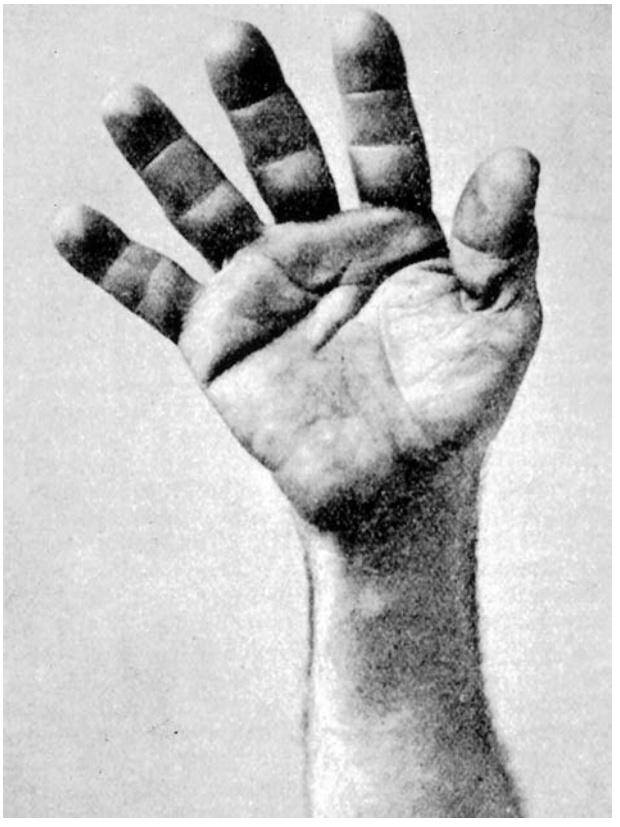


FIGURE 24-3 Spade hand in acromegaly. (From Osborne OT. Acromegaly. In: Buck AH, ed. *A Reference Handbook of the Medical Sciences*. Vol. I. New York: William Wood and Company; 1900;86–97, with permission.)

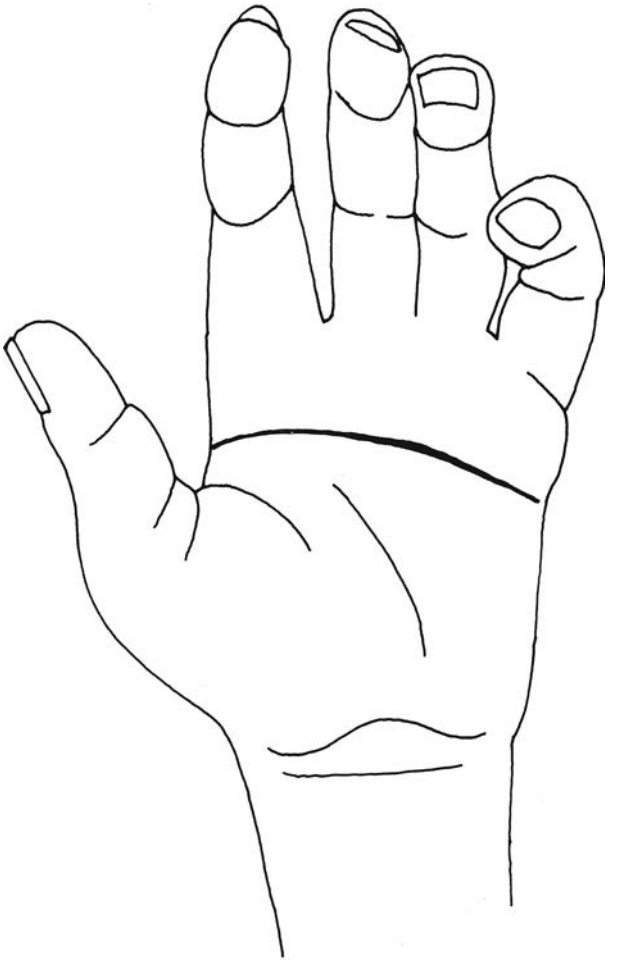


FIGURE 24-4 A simian crease.

Reiter syndrome, rare cases of disseminated gonococcemia, erythema multiforme (from any of its causes), and roseola—and arsenical and other hyperkeratoses, which are confined to the palms and soles. Palmar keratoses, especially when multiple, may be associated with arsenic toxicity. Skin, bladder, and lung cancer may also be associated with palmar keratoses (Cuzick et al., 1984), but here the keratoses may be few or single. (For a discussion of other keratoses, see Chapter 7.) Palmar and finger crease xanthomas are also discussed in Chapter 7.

Hyperpigmented macules and patches of the palms were present in 35% of black adults and in more than 60% of those over the age of 65 (McDonald and Kelly, 1987).

Another diagnosis that can be made by shaking hands with the patient is hyperthyroidism. Dr Eugene Robin of California correctly diagnosed apathetic thyrotoxicosis in an elderly man who had orthopnea and warm moist palms.

Palmar Dermatoglyphs

In patients with Down syndrome, one may see a bilateral simian crease (Fig. 24-4), in which the normal (two) transverse palmar lines are replaced by a single line that completely crosses the palm. However, the diagnosis of Down syndrome should never be based on this finding in isolation (see Chapters 9 and 10 for more on Down syndrome).

If both transverse lines are maintained, but the proximal one completely crosses the palm, it is referred to as a Sydney crease (Fig. 24-5). It indicates an increased propensity to develop granulocytic leukemia. It is also seen in Down syndrome and congenital rubella (Wertelecki, 1979). It was first described by Purvis-Smith of Australia and shown to me by Dr W. Wertelecki of Alabama.

In ichthyosis vulgaris, there are extra vertical palm creases between the thenar and hypothenar eminences (Fig. 24-6).

The Dupuytren[1] Contracture

This condition may affect one or more fingers, most commonly the ring finger, almost always sparing the index finger and thumb (Fig. 24-7). It is caused by a stenosing tenosynovitis or fibrosis of the palmar tendons. During maximum attempted extension of the

[1] Dupuytren, being of humble origin, would probably never have become a physician were it not for the educational reforms that followed the French Revolution. These reforms consisted of lowering the barriers to, not the standards of, a medical education. Their success may be judged from the fact that Dupuytren went on to become a full professor, much feared but much respected by the students. At Dupuytren's funeral, when the hearse reached the medical school, the students stopped it, unhitched the horses, and pulled the hearse the remaining distance to the cemetery themselves.

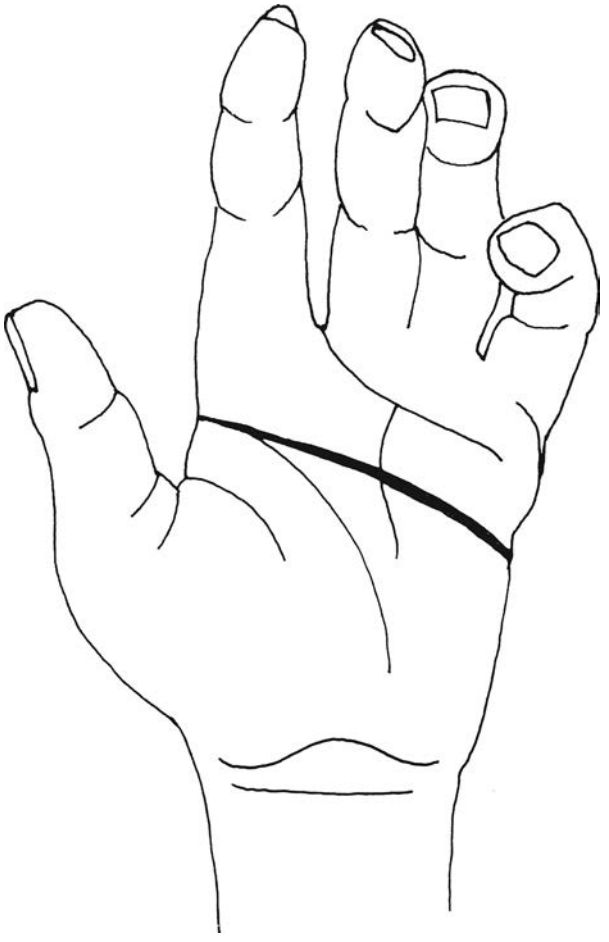


Figure 24-5 A Sydney crease.

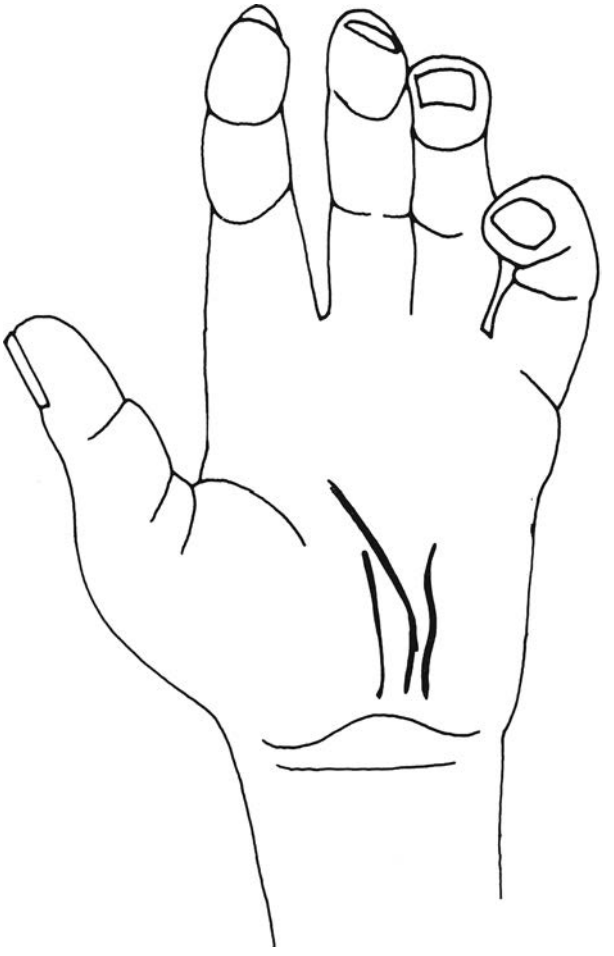


Figure 24-6 Palmar creases in ichthyosis vulgaris.

fingers, the afflicted fingers may be held in flexion. Sometimes the tendons can be felt better than seen.

The Dupuytren contracture especially occurs in older, white male patients who smoke cigarettes and have a family history of Dupuytren contracture (see Tables 24.5 and 24.6 for associations).

Osler Nodes and Janeway Lesions

In trying to determine whether a given case is more probably due to endocarditis or to another malignant process, I have found that attention to the position of the hemorrhages is at times very helpful. Several times I have noted numerous small hemorrhages with slight nodular character in the palms of the hand and the soles of the feet, when possibly the arms and legs had but a scanty crop in malignant endocarditis, whereas this has not been my experience with processes likely to be mistaken for it.

—E. Janeway, 1899; cited in Farrior and Silverman, 1976

Ephemeral spots of a painful nodular erythema chiefly in the skin of the hands and feet. . . . The spots came out at intervals as swollen areas, some the size of a pea, others a centimeter and a half in diameter, raised, red, with a whitish point in the center. I have known them to pass away in a few hours but more commonly they last for a day or even longer. The commonest situation is near the tip of the finger which may be slightly swollen.

—W. Osler, 1885 to 1909: cited in Farrior and Silverman, 1976

Red spots, some erythematous and some hemorrhagic, of a macular or papular nature, with or without a nodular and/or white

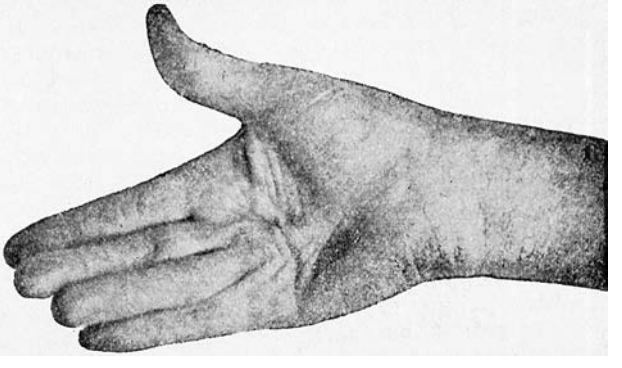


Figure 24-7 Dupuytren contracture, showing marked changes in the palm, with slight contraction of the ring and middle finger. (From Nichols JB. Hands and fingers, diseases and deformities of. In: Buck AH, ed. *A Reference Handbook of The Medical Sciences.* Vol. IV. New York: William Wood and Company; 1900:490–533, with permission.)

TABLE **24.5** *Prevalence of Dupuytren contracture in various diseases*

Disease	Prevalence (%)	References
Liver disease		Attali et al. (1987), Early (1962), Pojer et al. (1972), Su and Patek (1970), Wolfe et al. (1956)
Alcoholic cirrhosis	18–66	
Noncirrhotic alcoholic liver disease	19–22	
Nonalcoholic chronic liver disease	19–28	
Chronic alcoholism without liver disease	6–45	Hueston (1960)
Control groups	1–12	
Tuberculosis (chronic pulmonary)	13–42	Hueston (1960)
Epilepsy, treated	8–56	Critchley et al. (1976), Pojer et al. (1972)
Men over 60 years of age	>35	Hueston (1960)
Possible, but not proven		
Systemic lupus erythematosus		
Fibrosing diseases other than Peyronie disease		Dalinka and McGee (1970), Lund (1947)
Coronary artery disease		Hueston (1960), Kehl (1943)
Disproven		
Manual labor		Hueston (1960)
Brewery workers		Hueston (1960)

center, may appear on the hands, feet, digits, toes, and extremities of patients with acute, subacute, or chronic bacterial endocarditis or endarteritis.

Dr J.A. Mullin of Canada first showed these lesions to Osler in 1893 (Farrior and Silverman, 1976), although they had already been described by Lancereaux (Yee and McAllister, 1987). During the time of Osler's writing, Janeway described "his" lesion. The only remaining distinction between them (Farrior and Silverman, 1976) devolves on the arbitrary statement that Janeway lesions are never painful or tender. However, there is no basis for this distinction in Janeway's own description (*vide supra*), and no less an authority than Kerr has given us the clinicopathologic correlation between a tender Janeway spot and an Osler node (Kerr, 1955; Kerr and Tan, 1979). Probably, tenderness depends on whether neural structures are involved (Kerr and Tan, 1979; von Gemmingen and Winkelman, 1967).

I cannot tell the difference between the two. For those wishing to maintain a distinction, I will simply note that on occasion "both" have been shown to result from septic emboli based on Gram stain

TABLE **24.6** *Prevalence of other diseases in persons with Dupuytren contracture*

Disease	Prevalence (%)	References
Alcoholism	31–48	
Peptic ulcer	18–31	
Cholecystitis	10–34	
Diabetes mellitus especially correlated with retinopathy	6–25	Larkin and Frier (1986)
Glucose intolerance	93	Nardoni et al. (1981)
Cirrhosis	7–9	
Peyronie disease	2.4	
Chronic hepatitis	2.4	

From Pojer J, Jedlickova J. Enzymatic pattern of liver injury in Dupuytren's contracture. *Acta Med Scand.* 1970;187:101–104, with permission.

or culture of the lesion or the nearby tissue (Alpert et al., 1976; Cross and Ellis, 1966; Fanning and Aronson, 1977; Kerr, 1955; Lin et al., 1980; Puklin et al., 1971), and at other times "both" have been sterile and have been shown to arise from an immune vasculitis (Farrior and Silverman, 1976; von Gemmingen and Winkelman, 1967).

In the preantibiotic era, the lesions were found in 40% to 90% of cases of endocarditis but are now reported in only 10% to 23% of cases (Thapar et al., 1978; Yee and McAllister, 1987). The pronouncement that they are now rarely seen should be amended to read that they are now rarely *recognized*...in some quarters.

Differential Diagnosis

Lesions have also been seen in lupus erythematosus (Farrior and Silverman, 1976), infected intra-arterial lines (Michaelson and Walsh, 1970), bacteremia without endocarditis, gonococcal sepsis, typhoid fever, hemolytic anemia (Fanning and Aronson, 1977; Yee and McAllister, 1987), and nonbacterial thrombotic (marantic) endocarditis (Yee and McAllister, 1987).

Finger Signs

Digital Gangrene

Digital gangrene (Figs. 24-8 and 24-9) can occur in a variety of embolic and immune complex diseases, such as subacute bacterial endocarditis, polyarteritis nodosa, SLE, and atheromatous embolization, as well as in frostbite, cryofibrinogenemia, cryoglobulinemia, and progressive systemic sclerosis. However, if the lesions do not have a sharply demarcated border, or are *not* in the distribution of the terminal artery (i.e., at the fingertips), or if the lesion is single, one may well be dealing with posttraumatic ecchymoses, an especially frequent red herring in the foot.

Some experts expect cryoglobulinemias to produce lesions on the toes more frequently than on the fingers because the toes tend to get colder.

Figure 24-8 This patient with mixed cryoglobulinemia has digital gangrene. How can you distinguish his thumb lesion from a simple posttraumatic ecchymosis? (See Appendix 24.3 for the answer.) It may be debated that the above legend is incorrect in referring to "this patient" because it describes a photograph of just the thumb. In point of fact, most pictures are not pictures of an entire person, but only of the face, head, bust, and so forth. The thumb is no less noble than any other portion of a person. More importantly, the advanced reader should form the habit of referring to all parts of Smith as being Smith himself because of an unfortunate occurrence during the physician's maturation: As he becomes technically confident, the physician begins to see the individual parts as being somehow greater than, and also different from, the whole. You can see this occur in others more easily than in yourself. At bedside rounds, senior students will often touch another person's patient in order to examine a finding but will not even say so much as "May I?" or "Excuse me, please" to the patient. This happens with otherwise polite persons who suddenly become so interested in a part that they forget that it is a part of a person. Thus, this figure is truly a picture of Smith, not just of his thumb.

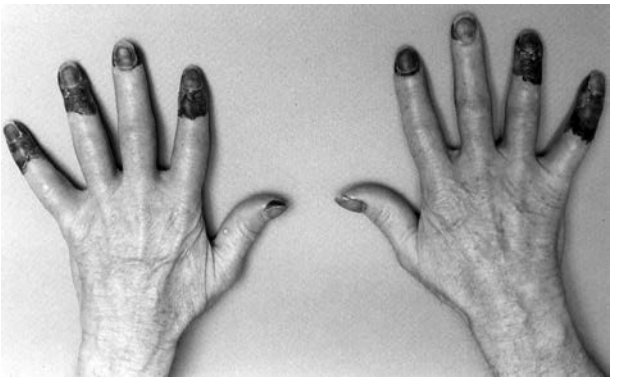


Figure 24-9 Diagnosis? Write your answer down, and then see Appendix 24.4. (Courtesy of Dr Renee Ridzon, Massachusetts.).

Other Finger Markings

Distal purpleness of the fingers, resembling the cyanotic phase of the Raynaud phenomenon (see also Chapter 18), may be seen in dermatomyositis, and less commonly in the other collagen vascular diseases, such as SLE or progressive systemic sclerosis. The most specific finger sign for dermatomyositis is Gottron knuckle patches, which are violaceous, flat-topped papules over the extensor surfaces of the interphalangeal joints. These are present in about one third of cases.

Black stains may appear under gold rings during exacerbations of diabetes mellitus, in psychotic depression, and during the first few days of the menstrual period. The substance responsible for this may be the same as the one that appears on the skin of menstruating women, which hastens the death of flowers touched by their hands (Reid, 1974).

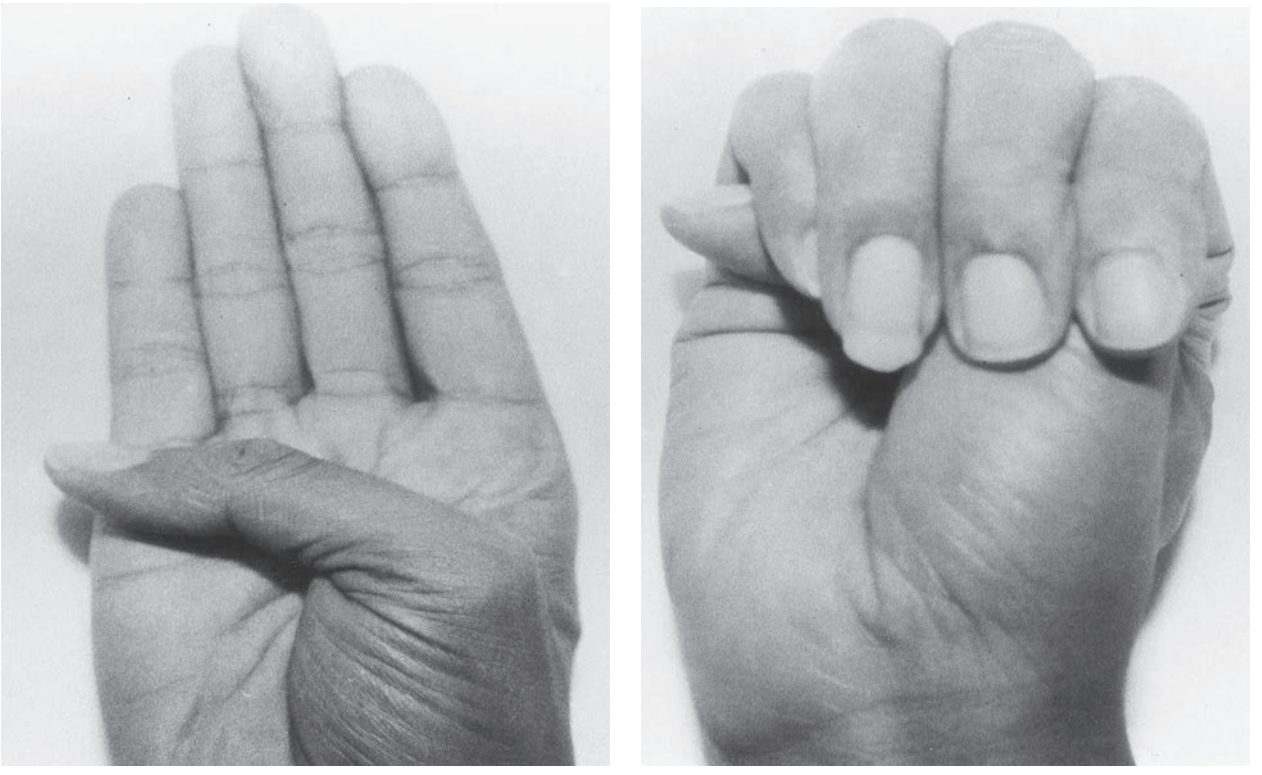
Brachydactyly

Brachydactyly may be seen as part of the trichorhinophalangeal syndrome, type I (Giedion syndrome), which is further characterized by sparse and slowly growing hair, a long pear-shaped nose, clinodactyly (a permanent lateral or medial deviation of one or more fingers), and sometimes multiple exostoses and Perthes disease of the hip. Type II may have mental retardation, microcephaly, and skin and joint laxity (Howell and Wynne-Davies, 1986).

Brachydactyly or a unilaterally small hand may be seen in association with Poland syndrome (see Chapter 15).

Arachnodactyly

This word literally means "spider fingers." In 1896, Marfan described only the skeletal aspects of what is now called *Marfan syndrome* in a 5-year-old whose long thin delicate fingers were flexed



A B

Figure 24-10 The Marfan thumb sign. **A:** A patient with The Marfan syndrome showing the thumb sign with his fingers still extended. **B:** The same patient after making a fist. (Courtesy of Dr Renee Ridzon, Massachusetts.)

by fibrous contractures so as to make them resemble the bent legs of a spider (Eldridge, 1964). Six years later, Achard suggested the term *arachnodactyly*. The term is now used to refer to the thin long fingers, without the contracting fibrous bands, which are rather unusual even in Marfan syndrome. In the Ghent nosology (Dean, 2002), the thumb and wrist sign are both required to diagnose this skeletal feature of Marfan syndrome.

To elicit the Marfan thumb sign, have the patient open his hand and cross his thumb across the palm as far as possible (Fig. 24-10A). Next, have him fold the fingers down across the thumb (Fig. 24-10B). The test is positive if any part of the tip of the thumb can be seen sticking out beyond the ulnar surface of the fist. (Compare with yourself.) This sign, not described by Marfan, occurs in Marfan syndrome, in its various formes frustes, in Ehlers–Danlos syndrome, and in other conditions of joint hypermobility. If the entire thumbnail projects beyond the ulnar border of the hand, the patient has the Steinberg sign.

In the Walker–Murdoch wrist sign, the distal portions of the thumb and fifth digit overlap when encircling the patient's own opposite wrist.

Marfan syndrome is also discussed in Chapters 5, 10, 13, 16, 17, and 18. Although inherited as an autosomal dominant with a prevalence of about 1 in 9,800, only about 26% of patients have a family history; presumably, new mutations are common. Manifestations are quite variable. Early diagnosis is important because treatment with β blockade may reduce the rate of aortic dilatation, and activities such as contact sports and scuba diving (because of the risk of precipitating pneumothorax) may be inadvisable (Dean, 2002).

Sclerodactyly

In sclerodactyly, the DIP folds are lost. To make this more clear, have the patient maximally flex all interphalangeal joints. (Many patients with severe scleroderma are unable to do this.) If one examines one's own DIP skin lines, one will see that they are retained during flexion. (Dr Margaret MacLachlan of Pennsylvania taught me this trick.)

Sclerodactyly is so frequent in progressive systemic sclerosis (scleroderma) that the clinical neophyte should probably not diagnose it in the absence of the finding.

Note that in rare cases, persons over the age of 40 will have sclerodactyly diagnosed by the test described above without having scleroderma. I have also seen it several times in patients with carcinoma of the esophagus. The reason for such an association is unknown.

Other Hand Findings

Fingernails (including the nail beds and clubbing of the fingers) are discussed in Chapter 7.

A careful look at the hands is an important part of the cardiac examination. Many signs (such as clubbing, cyanosis, edema, skin findings) are covered elsewhere in the book. Some congenital hand and finger anomalies associated with cardiac defects are listed in Table 24.7.

The earliest manifestation of sickle cell disease in infants may be a hand–foot syndrome, with painful, symmetric swelling of the dorsa of the hands, or feet, or both. This sign of sickle cell crisis

TABLE **24.7** *Hand anomalies associated with cardiac defects*

Syndrome and findings	Cardiac condition
Hurler syndrome (broad hand with stubby fingers, clinodactyly, flexion contractures)	Endocardial fibroelastosis, coronary artery atherosclerosis, and valvular thickening
Turner syndrome (hypoplastic fingernails, lymphedema, clinodactyly, shortened fifth finger)	Coarctation of the aorta
Polydactyly	Ventricular septal defects
Ellis–van Creveld syndrome (polydactyly, dystrophic nails)	Single atrium
Laurence–Moon–Biedl–Bardet syndrome (polydactyly)	Variety of congenital defects including patent ductus arteriosus, complete transposition of the great vessels, valvular pulmonic stenosis, dextrocardia, hypoplastic aorta
Holt–Oram syndrome (thumb resembles a finger)	Secundum atrial septal defect
Marfan syndrome (see text)	Aortic, mitral, or tricuspid regurgitation; aortic dissection; redundant chordae tendinae; aneurysms of the sinus of Valsalva
Rubenstein–Taybi syndrome (broad thumbs, great toes)	Patent ductus arteriosus, double aortic arch, pulmonic stenosis
Enlarged digit or marked asymmetry in size	Arteriovenous fistula
Trisomy 17–18(E) (tightly clenched fist, index finger overlaps third finger, fifth finger overlaps fourth)	Ventricular septal defect, patent ductus arteriosus, abnormal fleshy valves
Down syndrome or Trisomy 21 (simian crease)	Atrioventricular canal defect, ventricular and atrial septal defects, valvular anomalies, patent ductus arteriosus
Noonan syndrome (simian crease)	Pulmonic stenosis

From Silverman ME, Hurst JW. The hand and the heart. *Am J Cardiol.* 1968;22:718–728, with permission.

occurs exclusively in children younger than 8 years of age (Watson et al., 1963).

Calluses and abrasions on the dorsal surface of the hands may be acquired by a patient with bulimia in the course of inducing emesis. These are produced by the patient's teeth (Wynn and Martin, 1984).

Lower Extremities

Podagra

Podagra is Greek for pain in the foot. In current usage, it generally means pain at the first MTP joint. Although this is a classic location for gout, there are other etiologies for pain in this joint (Table 24.8).

Lipoatrophy

Lipoatrophy can be seen and (usually) palpated as the abrupt absence of fat under the skin. Lipoatrophy may be seen on any part of the body, as in SLE, and at sites of injection of insulin, triamcinolone, iron dextran, or diphtheria/pertussis/tetanus vaccine. If it is found on the lower extremities of a febrile patient, it suggests the diagnosis of Weber–Christian disease (relapsing febrile nodular panniculitis).

Lipoatrophia semicircularis, a form of pseudolipoatrophy that occurs most commonly in young women, consists of symmetric bilateral bandlike depressions on the anterolateral aspect of the midthighs. The asymptomatic lesions develop over a period of weeks, persist for a variable period, and may have spontaneous, total, or partial remissions as well as recurrences. They may result from repetitious external mechanical trauma. One young woman who had no history of trauma or familial metabolic diseases had a remission of lesions when she stopped wearing tight blue jeans (Mascaro and Ferrando, 1982). However, her sister developed similar lesions after wearing the same pair of jeans for 2 weeks (Mascaro and Ferrando, 1983).

These cases show the importance of taking a broad view of the patient's problem. They also provide an example of a disease that is familial without being either congenital or inherited and transmissible without being infectious.

Lower Extremity Changes Found in Diabetics

Necrobiosis Lipoidica Diabeticorum

Necrobiosis lipoidica diabeticorum is a pretibial lesion, the color of dried blood, and begins as a plaque with sharp borders. Then it becomes shiny and atrophic and may ulcerate. It is almost pathognomonic for diabetes mellitus but it is very rare.

Xanthoma Diabeticorum

Any eruptive xanthoma (described in Chapter 7) occurring in a diabetic can be called *xanthoma diabeticorum*. These are round papules not plaques.

TABLE **24.8** *Etiologies of podagra*

Gout
Pseudogout (calcium pyrophosphate dihydrate deposition)
Calcium hydroxyapatite
Less frequent causes
Rheumatoid arthritis
Osteoarthritis
Mechanical
One-upmanship causes
Sarcoidosis
Ankylosing spondylitis
Reiter syndrome
Psoriatic arthritis
Arthritis reactive to inflammatory bowel disease
Charcot joint of syphilis, diabetes mellitus, etc.
Infectious
Paget disease
Hemochromatosis
Striped unicorns[a]
Sesamoiditis
Pancreatic disease
Thyroid acropachy
Palindromic rheumatism
"Psychogenic" rheumatism

[a]A striped unicorn is an imaginary zebra (see Chapter 27).
From Bomalaski JS, Schumacher HR. Podagra is more than gout. *Bull Rheum Dis.* 1984;34:1–8, with permission.

Diabetic Shin Spots

Also called "diabetic dermopathy," diabetic shin spots are sharply circumscribed, depressed, atrophic shin patches that look as if the patient had bumped his shins on a coffee table (with poor healing and scarring), although most patients with the lesion recall no such events. Their prevalence is 49% in juvenile-onset diabetics, 46% in adult-onset diabetics, 20% in nondiabetic endocrine patients, and 1.5% in nondiabetic medical students (Danowski et al., 1966) (review Fig. 7-1 and Appendix 7.1).

Shin spots are different from the papules of perforating collagenosis, another skin sign of diabetes mellitus (discussed in Chapter 7), which also has a predilection for the extensor extremities.

Pretibial Myxedema

Pretibial myxedema is a violaceous induration of the skin, first described by Osler (Graner, 1985), and is observed over the shins and sometimes over the dorsum of the feet. Despite its name, it is associated with hyperthyroidism, *not* hypothyroidism (mnemonic: myxedema does not cause myxedema).

The word *myxedema* just means "slimy edema." Thus, any liquid swelling accompanied by a noncellular proteinaceous component is myxedema, be it the generalized subcutaneous form of hypothyroidism (from which the disease takes its other name) or this peculiar localized cutaneous form of hyperthyroidism.

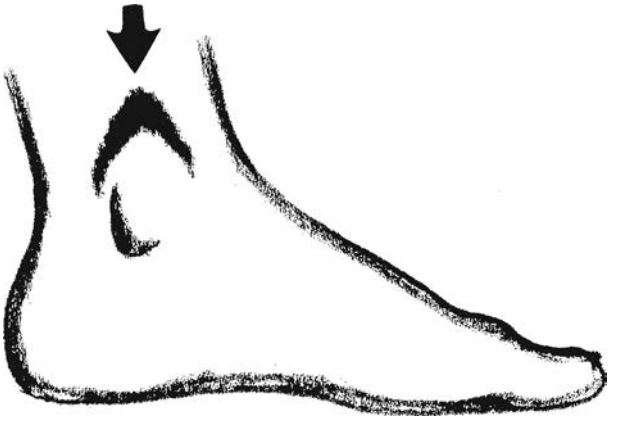


Figure 24-11 Following the rupture of a Baker cyst (or other cause of a calf hematoma), the blood dissects down the fascial planes and emerges as a crescent either above the malleolus (as shown) or sometimes below it. As the Baker cyst was often missed prior to rupture, the early signs of leg tenderness and swelling point to the erroneous diagnosis of thrombophlebitis. However, the delayed emergence of the crescent or meniscus sign permits the confident diagnosis of "pseudothrombophlebitis," which of course requires no anticoagulation.

Erythema Nodosum[2]

Erythema nodosum literally means "knotty redness" or red nodes, which can occur anywhere but are most characteristic pretibially. At one time thought to be a dermatologic equivalent of rheumatic fever, it is now recognized as a nonspecific although highly enlightening skin sign of a wide variety of diseases whose only common denominator seems to be an allergic component in the acute stages. Thus, it is seen during acute activations or onset of tuberculosis, coccidioidomycosis, lymphoma, ulcerative colitis, and leprosy (if it can be said to have an acute phase), and in a wide variety of drug reactions. It is most useful in (a) excluding the diagnosis of rheumatoid arthritis and most seronegative spondyloarthropathies, and (b) making the diagnosis of sarcoidosis since the combination of bilateral hilar lymphadenopathy with erythema nodosum is so certain to be sarcoid that biopsy is not required (Winterbauer et al., 1973).

Ecchymoses

The crescent sign of *pseudothrombophlebitis* (Good and Pozderac, 1977; Kraag et al., 1976) is shown in Fig. 24-11. Common causes of nontender ecchymoses of the leg are trauma, venous stasis, sclerosis of superficial vessels, and coagulopathy.

Most of the latter are painless when seen, not associated with swelling of the calf, and hence not likely to be confused with thrombophlebitis. (The ecchymoses of scurvy are discussed in Chapter 7.)

[2] Why do we say, correctly, erythema nodos*um*, when we say polyarteritis nodos*a*? Although it would seem that erythema is a first declension feminine noun (so that the modifying adjectives would also end in *a*), it is actually a Greek noun (meaning redness, as in erythrocyte). Thus, it is in group IV of the third declension, whose nominative singulars end in *a* but whose gender is neuter.

Chronic Venous Insufficiency

A swollen, brawny hyperpigmented pair of lower extremities with an ulcer near the medial (internal) malleolus permits the diagnosis of chronic venous insufficiency or stasis simply by inspection (also see Chapter 19).

Venous thrombosis is discussed in Chapter 19.

Edema

The Starling equation[3] describes the rate of edema formation:

$$J_v = k\left[(P_i - P_0) - \sigma(\pi_i - \pi_0)\right]$$

Dependent edema is usually demonstrated pretibially. However, there are some cases of very slight dependent edema that appear first in the more dependent foot; in bed-bound supine patients their extra interstitial fluid accumulates at the sacrum. Wherever the edema, its extent has been traditionally graded from 1+ to 4+. This may now be abandoned, as loop diuretics will quickly convert the latter to the former, and one is more interested in the simpler question of whether the edema is present or absent. If present, one wants to know how far up the body it goes, since the 1+ pitting edema reaching the chest wall may be more significant than the 3+ pretibial edema.

The pit recovery time (i.e., not how deep is the pit one's finger can make, but how long it takes for the pit to refill) is a very valuable diagnostic sign.

A Method for Pit Recovery Time

Although the original method for pit recovery time used a constant pressure device, I have attempted to modify the test so that it can be done with the fingers. The neophyte is advised to start with a few patients of known serum albumin and try to find the amount of pressure that reproduces the results (Fig. 24-12) described by the original authors (Henry and Altmann, 1978).

1. Press down firmly all the way to the bone. Start the stopwatch.
2. Shine a light at a tangent across the pit and do not call the pit recovery time until there is no shadow remaining anywhere in the area of the pit.

The test is very crude. After 10 years of practice, one still makes mistakes in the 35 to 40-second range. Notice the scatter around the regression line given in the original paper (Fig. 24-12).

Interpretation

In *acute* edema (i.e., of <3 months' duration), there is a direct relation between the serum albumin concentration and the pit recovery time (Henry and Altmann, 1978). Thus, in hypoalbuminemic edema, the pit recovery time is very short (i.e., 40 seconds or less) (see Fig. 24-13 for an example of a short pit recovery time).

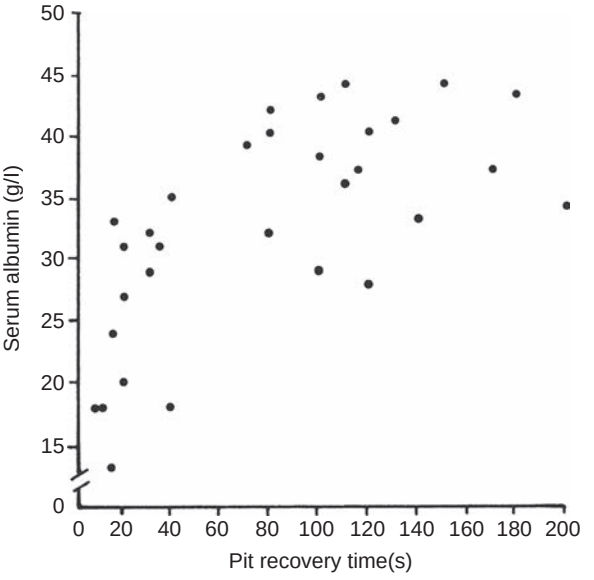


Figure 24-12 Relation between serum albumin concentration and pit recovery time in 31 patients. (From Henry JA, Altmann P. Assessment of hypoproteinemic edema: A simple physical sign. *Br Med J.* 1978;1:890–891, with permission.)

In the edema caused by congestive failure, or other causes of increased venous pressure in the lower extremities, the pit recovery time will regularly be more than 40 seconds, provided hypoalbuminemia is not also present (see below for a more complete differential diagnosis).

In capillary edema (as opposed to lymphedema; *vide infra*), the pit recovery time is greater than 40 seconds if the serum (and tissue) albumin is normal. (Capillary edema results from increased permeability of the capillaries, as in vasculitis, in idiopathic edema of women, and after total-body anoxia.)

I have seen at least one patient with an unrelated *low* serum albumin and postanoxic edema in whom the pit recovery time was still greatly prolonged. Perhaps in postanoxic edema, the permeability coefficient of the Starling equation is changed and the pressures and protein concentration become less important.

It is stated that some cases of glomerulonephritis have a high protein content and a long pit recovery time; these are obviously nonhypoalbuminemic nonnephrotic cases (Henry and Altmann, 1978).

During hot weather, aldosterone concentration increases in normal persons and the serum albumin stays normal, but pedal edema (especially observable at the top of elastic socks) may be seen in the evening, especially if the individual is in an occupation requiring him to stand all day. This normal edema also has a long pit recovery time, presumably because the edema has a normal (high) protein concentration.

I have additionally observed a peculiar inexplicable two-component pit recovery time in which the edema begins to recover very quickly and then turns out to have a delayed pit recovery time. This is seen in the *combination* of increased venous pressure and hypoalbuminemia, most commonly in cirrhotic patients with severe ascites compressing the inferior vena cava and concomitant hypoalbuminemia due to impaired hepatic synthesis.

[3] J_v is the rate of fluid formation, k is the filtration coefficient (which is related to permeability), P is hydrostatic pressure, π is oncotic pressure, and σ is the permeability coefficient whose change is probably most important for postanoxic states (*vide infra*). The subscript o refers to pressures outside the vessel (membrane), and the subscript i to the pressure inside.

FIGURE 24-13 A short (fast) pit recovery time. **Top:** On being told of a patient with pitting edema and a normal albumin, I went to take a picture of his pit recovery time, which I expected to be prolonged (see text). In the top view, you can see two pits made with my thumb, one in the center and one made just before it, to the right. (Ignore the *arrow* for now.) **Bottom:** After taking the top picture, I quickly advanced the film in the camera, reset the flash, and brought it back to my eye for focusing. The pit had already disappeared! (In fact, the lower picture shows a completely different distribution of hairs and a different focal plane, as I had to hunt for the pit that had so quickly disappeared. However, it is the same region of the same foot. The lesion to the left was cropped out of the upper photograph; the edge is marked by an *arrow*.) Do not attempt the following questions until you have finished reading the chapter:

1. This is surely a quick pit recovery time, but what could have caused it? If it is true that the pit recovery time is proportional to the interstitial protein concentration (and it is), then how could a patient with a normal serum albumin have a fluid with such a short pit recovery time?
2. What will the pit recovery time be in 4 months? (Write your answer down before consulting Appendix 24.5.)

I had one patient with congestive heart failure and nephrotic syndrome due to Kimmelstiel–Wilson disease, in whom there was a two-component pit recovery. However, a measured serum albumin was normal! It later became apparent that he had experienced a precipitous fall in his glomerular filtration rate just prior to admission, which was associated with a precipitous fall in his (measured) proteinuria. This apparently permitted his liver to "catch up" and his comparatively low serum albumin to rise to a normal level at the time I saw him. This case confirms the original authors' contention that the quick pit recovery time (component) is a reflection of the albumin level in the interstitium not just in the serum.

Finally, it must be reemphasized that in all the above cases, we are talking about acute (<3 months' duration) edema. If the edema is chronic, the scarring and fibrosis in the interstitium will make *all* types of edema have a prolonged pit recovery time because the fibrous and collagen strands will demarcate the pit and produce a slow pit recovery even in the presence of pure hypoalbuminemia (Henry and Altmann, 1978).

Differential Diagnosis of Pitting Edema

Pitting edema is a leading sign and symptom whose pathophysiology has been understood for half a century. Furthermore, there is a discrete number of items in the differential diagnosis (Table 24.9). Each of these items has specific and characteristic physical findings apart from the edema itself. The first branch point (hypoalbuminemia versus increased venous pressure) can even be achieved without a laboratory by utilization of the pit recovery time.

Unilateral edema suggests venous thrombosis, previous or recent trauma or surgery, infection, malignancy, or radiation therapy. Edema resulting from cellulitis, osteomyelitis, or burns does not usually present a diagnostic difficulty. Rupture of the medial head of the gastrocnemius (see Chapter 25) causes unilateral leg edema lasting up to 6 weeks (Powell and Armstrong, 1997).

A Note on Terminology for the Advanced Student. An increase in venous pressure, comparable to that seen in congestive heart failure, reduces the flow of lymph in the thoracic duct. This decrease in lymphatic clearance contributes to fluid accumulation in the interstitial spaces (Wegria et al., 1963). Thus, the edema found in the leg in congestive heart failure might be called, correctly, "lymph" or "lymphedema." In this text, however, lymphedema is a term reserved for the interstitial fluid accumulation of pure lymphatic disease (*vide infra*).

Lymphedema

Lymphedema may be classified by age of onset or by etiology (Stone and Hugo, 1972).

At Birth

Lymphedema at birth may be caused by prematurity, from amniotic bands, from congenital lymphangiectasia (Goodman, 1962), or from Milroy's form of congenital familial lymphedema (Nonne, 1890; Milroy, 1928).

In Childhood

Lymphedema appearing after birth, but before age ten, could be a familial form such as Meige disease. Or it could be secondary to Turner, Bonnevie–Ulrich (Goodman, 1962), or Noonan syndrome (Mendez and Opitz, 1985) or even a congenital defect (Goldrick and Ahrens, 1964).

After Age 10

Between the ages of 10 and 29, most cases are primary (Meige disease), never malignant, and rarely infectious (Smith et al., 1963).

From 30 to 49 years of age, the idiopathic primary cases continue to appear and should probably carry the name "Kinmonth" (Schirger et al., 1962). These cases occur with a 10:1 female preponderance. In this same epoch, malignancy appears as an etiology and infectious causes become more prevalent, although both of these together make up only half the cases, the idiopathic cases still forming the other half (Smith et al., 1963).

TABLE **24.9** *Differential diagnosis of pitting edema*

I. Hypoalbuminemia
  A. Impaired synthesis
    1. Decreased intake of the amino acid precursors as in starvation or protein-calorie malnutrition (kwashiorkor)
    2. Decreased absorption of amino acid precursors as in malabsorption syndrome
    3. Impaired synthesis due to hepatic insufficiency
  B. Increased loss
    1. Skin loss—from burns, pemphigus, or other such "weeping" skin diseases including some drug reactions
    2. Urinary loss—nephrotic syndrome
    3. Fecal loss—for example, everything from Ménétrier disease to inflammatory bowel disease with azotorrhea; in some inflammatory bowel diseases, both malabsorption and azotorrhea occur at the same time
II. Increased venous pressure—this may be visualized by working backward from the heart down to the foot veins, as follows:
  A. Systemic venous hypertension
    1. Congestive heart failure
    2. Restrictive cardiac disease
    3. Tricuspid valve disease
    4. Constrictive pericarditis
    5. Pericardial tamponade
  B. Regional venous disease
    1. Inferior vena caval syndrome
    2. Venous thrombosis
    3. Lower extremity venous insufficiency
    4. Using round circumferential elastic thigh garters to hold up stockings; (this disease has been made obsolete by the pantyhose industry, but formerly one saw a case a year; as fashions tend to cycle it is included for prospective completeness)
III. Capillary edema due to increased permeability (rare and diagnostically obvious)
  A. Vasculitis (rare)
  B. Postanoxic syndrome
  C. Idiopathic edema of women (this also affects the hands and is cyclic)

In new cases appearing after age 50, malignancy is the primary consideration. Idiopathic cases should not have their onset this late, and infectious causes are waning.

More About Etiologies

For the Resident. The infectious causes can be secondary to the lymphedema (Schirger et al., 1962), or the lymphedema secondary to the recurrent infection (Young and DeWolfe, 1960). Or the lymphedema may simply be a transient consequence of lymph node enlargement and obstruction caused by an infectious disease, as in catscratch fever (Filler et al., 1964). Tumorigenic lymphedema is usually seen in men and is most likely to be due to prostatic carcinoma, which infiltrates the lymphatics. When it occurs in women, it is usually due to lymphoma, except for the peculiar situation of the Stewart–Treves syndrome: upper extremity lymphedema associated with (fatal) aggressive lymphangiosarcoma in asymptomatic female subjects who have previously had an ipsilateral mastectomy for breast carcinoma (Goodman, 1962).

As a rule, infectious causes have a 2:1 ratio in favor of women, and for the malignant causes, the sex preference is the exact reverse.

Bilaterality of lymphedema is seen in many of the congenital cases, in many of the infectious cases, and in sarcoidosis (Silver et al., 1966), but not in cases due to neoplasia (Smith et al., 1963).

Lymphedema may be part of the yellow-nail syndrome (see Chapter 7).

Pit Recovery Time

Initially, the pit recovery time should be quite short, as the edema fluid has a low protein content (Goodman, 1962) and the venous pressure and circulation time would be normal. However, with the passage of time, the tissues become brawny and fibrotic,

and as with hemic edema, the pit recovery time becomes prolonged strictly because of the chronicity of the process. Thus, in the Milroy (adult) index case, "Deep pressure with the finger over the crest of the tibia, at a point near its middle, produced a depression which was distinctly apparent to both touch and sight 10 minutes after the pressure was removed" (Milroy, 1892).

Consider the questions posed in the legend to Fig. 24-13. The answers are in Appendix 24.5.

Appendix 24.1

Answer to Self-study (Nodules in Rheumatoid Arthritis and Rheumatic Fever)

A diagnostic ratio may be computed as follows: 28% of the 95 patients with rheumatoid arthritis (26.6) would have nodules. Of these, 5% or 1.33 would appear on the occiput. Of the patients with rheumatic fever, 9% would have nodules (0.45), and 20% of these would be on the occiput (0.09). Thus, the ratio of patients with rheumatoid arthritis to that of patients with rheumatic fever with this finding would be 14.8:1.

This question reemphasizes the importance of prevalence. Although occipital nodules are rare among patients with rheumatoid nodules, and are four times more common among all patients with rheumatic fever with nodules, the relative prevalence of the disease would actually make an occipital nodule favor the diagnosis of rheumatoid arthritis in that physician's practice, all other things being equal.

Appendix 24.2

Answer to Question in Fig. 24-2 Legend

A: Porphyria cutanea tarda causes hypermelanotic pigmentation and atrophic scars, especially on the exposed surfaces of the hands and face. (Courtesy of Dr Renee Ridzon, Massachusetts.)

B: Rheumatoid vasculitis may also cause pinhead-sized hemorrhagic spots and necrotic areas. (Courtesy of *Consultant*, Cliggott Publishing Group of CMP Healthcare Media, Darien, CT and Dr Thomas E. Weiss, Alton Ochsner Medical Foundation, New Orleans, Louisiana.)

Appendix 24.3

Answer to Question in Fig. 24-8 Legend

First, a posttraumatic ecchymosis would never cause loss of tissue, such as digital pulp, muscle, and subcutaneous tissue. This thumb has obviously undergone considerable loss of volume distally. Second, the lesion is chronic, as evidenced by the scale; however, it is still dark. A posttraumatic ecchymosis might be dark acutely but would have faded by the time it became chronic.

Appendix 24.4

Answer to Question in Fig. 24-9 Legend

After celebrating the calends of February at a symposium, this gentleman walked home in a snowstorm. Losing his house keys in a snowbank, he searched for them with ungloved hands. The unsuccessful search leaving him weary, he decided there and then to retire for the night; he awakened with this classic case of frostbite not distinguishable from the other causes of digital gangrene without the history.

Appendix 24.5

A Note on the Pit Recovery Time: Answers to Questions in Fig. 24-13 Legend

If the pit recovery time is as short as indicated in Fig. 24-13, then the fluid *must* be hypoproteinemic. If the serum albumin is normal, the edema fluid cannot be coming from the blood vascular compartment. (Vasculitis and venous hypertension both produce edema fluids of high protein content [Henry and Altmann, 1978].) The only remaining conclusion is that the edema is actually *lymphedema* (see above).

The answer to the second question in the legend is that the pit recovery time would eventually become prolonged, assuming that the lymphedema had not resolved.

This particular patient had lymphedema secondary to Kaposi sarcoma, a spot of which can be seen on the left.

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CHAPTER

25

The Musculoskeletal System

Since men's bodies are symmetrical as to arms and legs, one should use the sound in comparison with the unsound, and the unsound with the sound; not observing other people's joints (for some have more projecting joints than others), but those of the patient himself, to see if the sound one is dissimilar to the one affected. And though this is correct advice there is a good deal of fallacy about it. This is why it is not enough to know the art in theory only, but by familiar practice.

—Hippocrates, translated by E.T. Withington, 1928

Points to Remember:

- In addition to ailments affecting the rest of the body, the musculoskeletal system is especially subject to mechanical problems.
- Primary muscle weakness may be hereditary or acquired. Check endocrine status, electrolytes, and drug and vaccine history.
- Special maneuvers such as stressing the femur or auscultatory percussion may be useful in detecting fractures where radiographic facilities are normal—or even when radiography is falsely negative.
- The pain diagram may contribute 85% of the information that a skillful physician needs to make a diagnosis. But remember that there is great individual variation, and that patterns of pain do not necessarily follow the distribution expected from dermatomes and peripheral nerves.
- To avoid missing mild weakness in powerful muscles, the examiner needs to give himself every mechanical advantage in resistance testing, exercise the muscles to the point of fatigue, or use another appropriate method.
- In any patient with neck or back pain, the general physician should first rule out neurologic compromise, and then check for signs of medical causes such as infection or neoplasia.
- Tendon injuries in the hand, which require early repair for best results, are likely to be missed unless specifically sought.

This chapter concerns primarily bones, muscles, joints, and ligaments, along with the nerves that are closely associated with them. The connective tissues of the body can be affected by the usual types of diseases (inflammatory, infectious, neoplastic, vascular, etc.) but can, in addition, be subjected to mechanical disorders often resulting from trauma.

Pain or dysfunction in this system can be caused by neurologic problems and can also be the cause of neurologic problems, as by pressure on nerves or nerve roots. One can properly speak of the neuromusculoskeletal system, as all of these components work together. The central neurologic component is considered later (see Chapter 26), primarily because of tradition, but the two chapters should be studied together. The neurologic examination is done in conjunction with the musculoskeletal examination.

Muscle Disorders

Myopathies

Key Findings

Weakness due to primary muscle disease or myopathy is often characterized by proximal (girdle) weakness, usually with relative preservation or even increase in muscle bulk. The earliest manifestations are difficulty in rising from the sitting position and difficulty with actions involving repeated vigorous hand movements with the arms held above shoulder level (as in combing the hair). The former is called the *Gower sign*. In arising from the floor, the patient uses his hands to climb up his thighs. If not pathognomonic, this sign is highly suggestive of Duchenne muscular dystrophy of the pseudohypertrophic type (J. Dwyer, *personal communication,* 1999).

Patients with statin-related myopathy may not report weakness unless specifically asked about the ability to perform daily activities such as climbing stairs, getting in or out of a car, or lifting heavy items (Dobkin, 2006).

Patients who have proximal weakness can be demonstrated on resistance testing (*vide infra*). The patient may develop a broad-based gait, with waddling of the pelvis due to weakness of the glutei. Testing the strength of individual muscles is described below.

The "Timed Stands" Test

To evaluate and follow up patients with polymyositis, the following standardized test has been described (Csuka and McCarty, 1985).

Using a stopwatch, measure to the nearest tenth of a second the time required for a subject to complete ten full stands from a sitting position in a plastic molded straight-backed chair 44.5 cm high and 38 cm deep. Subjects are permitted one practice stand to learn the task and are then encouraged to perform it as quickly as possible. Use of the arms is not allowed. Subjects with symptomatic arthritis, morbid obesity, or incapacitating lung or heart disease cannot perform the task. Normal times in women varied from 10.9 seconds at age 20 to 21.8 seconds at age 85, and for men, normal times ranged from 8.8 seconds at age 20 to 21.5 seconds at age 85. The prediction equations were as follows: for women, time (seconds) = 7.6 + 0.17 × age and for men, time = 4.9 + 0.19 × age.

Of course, this test, which evaluates endurance rather than just momentary force, can be used to follow patients with any cause of muscle weakness. Patients with weakness by other criteria may show good strength on resistance testing for one or two repetitions but fatigue rapidly.

Differential Diagnosis

The differential diagnosis of muscle disease includes hereditary conditions such as muscular dystrophy or glycogen storage disease; inflammatory conditions such as polymyositis; vitamin D deficiency rickets; and endocrine disorders such as thyrotoxicosis or Cushing syndrome, or corticosteroid ingestion.

There are a number of progressive, hereditary diseases called *muscular dystrophy,* each with unique phenotypic and genetic features.

It should also be remembered, however, that polyneuropathy, anterior horn cell disease, and other neurologic conditions can also cause proximal muscle weakness.

If the weakness is *distal,* think of a polyneuropathy such as Charcot–Marie–Tooth syndrome (peroneal muscular atrophy). This condition, which causes chronic degeneration of peripheral nerves and roots, beginning in the feet and legs and progressing to involve the hands, is inherited as an autosomal dominant.

Drug-induced myopathy may present insidiously with weakness, fatigue, and myalgia, or acutely as rhabdomyolysis. The most commonly implicated drugs are lipid-lowering agents, especially certain HMG-CoA (3-hydroxy-3-methylglutaryl coenzyme A) reductase inhibitors (lovastatin, fluvastatin, and simvastatin). A distal myopathy in conjunction with an autoimmune vasculitis has been reported with atorvastatin (Haroon and Devlin, 2008). Other drugs known to cause myopathy are alcohol, chloroquine, cocaine, corticosteroids, hydroxychloroquine, clofibrate, gemfibrozil, penicillamine, and zidovudine. Chinese herbal red rice, increasingly popular in the US, has been associated with myopathy, probably because it contains lovastatin (Smith and Olive, 2003).

An "emerging" inflammatory myopathy called *macrophagic myofasciitis* has recently been described (Gherardi et al., 1998). Patients present with myalgia and arthralgia. About 30% have muscle tenderness, and 14% have muscle induration but without wasting. About one third of patients have myopathic findings on electromyography. The histologic findings of infiltration by large macrophages are distinctive. In addition to the chronic fatigue and myalgias, up to 20% of patients develop a concurrent condition believed to be of autoimmune etiology, such as Hashimoto thyroiditis, dermatomyositis, rheumatoid arthritis, Sjögren syndrome, or a demyelinating condition (Gherardi and Authier, 2003).

Controversy has erupted over the proposed etiology of aluminum adjuvants in certain vaccines (Malakoff, 2000), including hepatitis B, anthrax, and tetanus; in 94% of 50 patients, the onset of myalgia was subsequent to a vaccine, with a mean delay of 11 months (Gherardi et al., 2001). No denominator is available to assess the prevalence of the association. The history might suggest an appropriate biopsy site. The differential diagnosis includes polymyositis and polymyalgia rheumatica.

Diffuse Muscle Tenderness

Generalized muscle tenderness may be found acutely in polymyositis; infectious diseases (malaria, rubella, influenza, rheumatic fever, dengue, rat-bite fever, and trichinosis); hyponatremia; hypokalemia; and myopathies, such as McArdle disease and march myoglobinuria. Chronically, the muscles may be tender in hypoparathyroidism, polymyalgia rheumatica, and other collagen vascular disorders.

Myotonia and Myoedema

One type of hereditary muscular dystrophy can be diagnosed by shaking the patient's hand. A patient with myotonia is unable to relax his hand after a handshake and so continues to grip your hand. (Of course, this must be distinguished from the intentionally held handshake of the disturbed patient who wishes to hold your attention as he speaks.) (See Chapter 13 for a method of diagnosing myotonia of the tongue.)

The most interesting of the myotonias is Thomsen disease or myotonia congenita. If you strike the muscles of the thenar eminence with a reflex hammer, they immediately undergo a prolonged tonic contraction. Thomsen disease causes lifelong myotonia but no other abnormalities and is quite benign.

The most common myotonia is myotonia dystrophica or Steinert disease, more often called *myotonic dystrophy*. This is the most common adult muscular dystrophy. The myotonia, initially demonstrable in the thenar eminence, tongue, and wrist extensors, becomes more difficult to detect as muscle wasting supervenes. Muscle weakness is distal rather than proximal, involving wrist and finger extensors and intrinsic muscles of the hand; neck flexors and sternomastoids, which become pencil-like; and ankle extensors, causing foot drop. These patients have what is known as a hatchet face owing to atrophy of the temporalis, masseter, and sternocleidomastoid muscles. Dysarthric speech and dysphagia may result from involvement of the tongue, pharynx, and palate, and respiratory insufficiency from intercostal and diaphragmatic weakness. Internal organs are also affected. Cardiac conduction abnormalities and mitral valve prolapse are common. Colonic and esophageal motility are impaired. Other problems include premature temporal baldness, testicular atrophy, cataracts, hypersomnia, and intellectual impairment.

Amenhotep IV, known as Akhenaton or the heretic pharaoh, is thought to have been afflicted. Statues and reliefs of him, with an artistic realism unprecedented in Egyptian art, depict characteristic features of this condition. Myotonic dystrophy may have put an end to the royal bloodline of the Eighteenth Dynasty in ancient Egypt (Cattaino and Vicario, 1999).

Eulenburg paramyotonia congenita is a very rare disease in which sudden spastic muscle contractions occur during or immediately after cold exposure.

Myotonia can also be seen in adynamia episodica (hyperkalemic periodic paralysis) and chondrodystrophic myotonia, among the naturally occurring diseases (Furman and Barchi, 1986). Vincristine and propranolol may unmask latent myotonia dystrophica, but other chemical substances may actually produce myotonia de novo (e.g., aromatic carboxylic acids, sulfhydryl-inhibiting parasubstituted mercuribenzones, and inhibitors of sterol synthesis including clofibrate). The roles of iodine and hypochloremia in some myotonic syndromes are even more obscure.

Myotonia must be distinguished from a different sign known by the misnomer myoedema, which is also elicited by direct mechanical stimulation of muscle. In myoedema, the muscle contracts slowly and relaxes at the same rate (about 1.5 seconds). This finding can be produced in almost anyone, given a sufficiently vigorous pinch on the biceps. However, it is easily produced in abnormal states by light percussion with a hammer. Myoedema is not specific

for neurologic or muscle disease and is seen with hypoalbuminemia and/or catabolism (Conn and Smith, 1965); myotonia, on the other hand, results from primary muscle disease. Myoedema normally requires a much harder striking force than myotonia, which can be elicited with a very light tap in some circumstances. Myoedema is not usually elicited on the thenar eminence; myotonia is. Finally, the after-contraction of myoedema (actually the failure of relaxation) is much briefer in duration than that of myotonia.

An Exercise for the Student

The sculpture sketched in Fig. 25-1 has what appears to be a myopathy. Note that the subject is unable to arise unassisted from the tailor position. This indicates disease of the pelvic girdle; when severe, the subject will also be unable to arise unassisted from a squatting position.

The position of the hands gives rise to speculation about a myopathy afflicting the shoulder girdle, but direct inspection of the shoulder girdle reveals no apparent atrophy; in fact, there might even be some hypertrophy. Accordingly, I believe that his upper extremities are simply postured in the synkinesia of a man with pelvic girdle weakness trying to arise (for more on synkinesia, see Chapter 26).

Given the above, what is your diagnosis? Write it down (the answer is in Appendix 25.1).

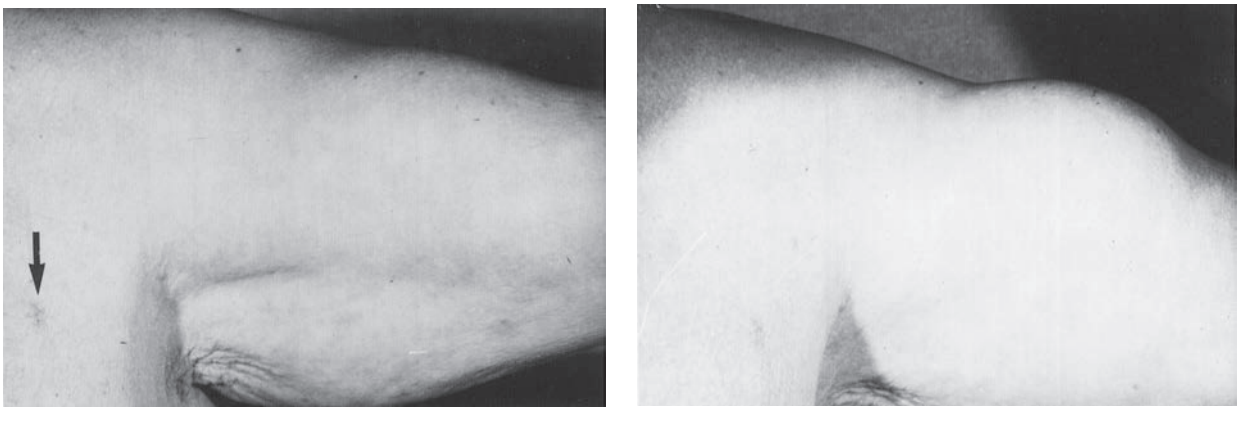
Figure 25-1 A case of myopathy (see text). (Drawing of a late Olmec period sculpture, Mexico City Museum of Anthropology.)

A Bulge in the Muscle

A ruptured biceps or other muscle will have a bulge that occurs only and always during contraction. In a reversal of the usual order for the clinical examination, the history should confirm the diagnosis. The patient can usually recall the exact time of onset. The appearance of the bulge immediately follows a violent effort and a popping sound. Associated symptoms are some discomfort on contraction and some weakness. In the absence of such a history, consider the alternate diagnosis of a muscle herniation through a defect in the covering aponeurosis. (As Dr Thomas Foley, a Chicago internist, frequently admonished the students and residents: "Hush, doctor, the patient is telling you the diagnosis.")

In part A of Fig. 25-2, the arm is extended at the elbow. All the muscle seen is of normal consistency. There is nothing hard on palpation. The photograph in B, with the elbow flexed, was taken just seconds after the first. The bulge is about halfway between the acromion and the elbow. It is the consistency of contracted muscle. What is your diagnosis? Write down your answer, and then see Appendix 25.2.

The most familiar tear occurs in middle-aged weekend athletes. "Tennis leg" is a partial tear of the gastrocnemius. It occurs with a sudden snap and severe pain. A hematoma develops, usually on the medial side of the calf near its midpoint. The foot is held in plantar flexion. The differential diagnosis includes thrombophlebitis, an incipient tear of the Achilles tendon, or a tear of the popliteus. With the last diagnosis, the patient can be instructed to continue his



A B

Figure 25-2 **A:** The biceps relaxed. The pointer indicates a spider telangiectasis. (It is poorly seen but demonstrates the usual size.) **B:** The biceps contracted. (See text.)

normal activities as tolerated. The other conditions require treatment: immobilization of a gastrocnemius tear to prevent a permanent flexion deformity, and immobilization of an incipient Achilles tendon tear to prevent a complete tear (J. Dwyer, *personal communication,* 1999).

Ruptured biceps tendon associated with simvastatin and ezetimibe therapy, with contralateral symptoms of biceps tendinopathy on rechallenge, has been reported. Statins are known to inhibit matrix metalloproteinases needed for physiologic tendon repair (Pullatt et al, 2007).

Scurvy had presented as a gastrocnemius tear in a 26-year-old serviceman. The diagnosis was made by a dermatologist more than 6 weeks after the injury when skin manifestations appeared in the hospital. Only then was the dietary history obtained; the patient ate only skinless chicken and candy bars (Keenan et al., 2002).

Rhabdomyosarcomas usually feel hard both during and between contractions, but may rarely *appear* to be a localized bulge, occurring only and always during contraction. In such cases, the contraction probably just throws the rhabdomyosarcoma into relief. Onset is gradual. Similarly, myositis ossificans, a rare condition, should not be confused with muscle herniation or muscle rupture since it will also be hard during muscle relaxation.

Bone

Inspection

Inspect bones for obvious deformity, asymmetry, abnormal position, or alignment.

A Method for Measuring the Legs (Length)

1. Have the patient lie supine on an examining table, with his pelvis level, his hips and knees fully extended, and both hips equally abducted or adducted.
2. Locate the anterior superior iliac spines and mark their lower margins. Alternatively, mark the symphysis pubis, which may be more readily identifiable, especially in obese patients.
3. Measure from the point marked in step 2 to the medial malleolus on the same side.

The most accurate method is to measure the length of the bones on a roentgenogram or bone scan. The latter is done before any leg lengthening or shortening procedures are planned (J. Dwyer, *personal communication,* 1999).

The measurement of leg circumference is discussed in Chapter 19.

Differential Diagnosis of Deformities and Multiple Fractures

Many congenital or nutritional conditions can cause multiple deformities or frequent fractures, which may occur with minimal trauma or even normal activity. Some of these conditions are complicated by misdiagnosis of child abuse, adding family separation to the trauma that must have been endured by the victims.

In osteogenesis imperfecta, radiographs may show continuously beaded ribs or crumpled long bones (accordina femora). Bones may be either unusually thick or unusually thin. There may be associated findings such as blue sclerae, excessive joint mobility, fragile skin, and discolored or brittle teeth, or the child may appear outwardly normal (Feibusch, 1993; Paterson et al., 1993). A great variety of fracture patterns may be observed (Paterson and McAllion, 1989; Dent and Paterson, 1991). Copper deficiency can cause skeletal anomalies similar to those seen in child abuse. The deficiency is reported in malnourished infants with chronic diarrhea who are on a milk-based diet; severely premature infants with low hepatic stores; or patients receiving long-term parenteral nutrition with inadequate copper supplementation. It also occurs in Menkes kinky hair syndrome, an X-linked disorder characterized by defective intestinal absorption of copper. Copper deficiency also causes neurologic, hematologic, and dermatologic abnormalities (Stewart and Rosenberg, 1996). It has been suggested that a temporary brittle bone disease secondary to decreased fetal movement may present with unexplained fractures (Miller and Hangartner, 1999; Miller, 2003). A paradoxical absence of bruising and other signs of trauma is a feature often seen with fractures secondary to bone disorders (Paterson, 1990).

These conditions are emphasized here because misdiagnosis of nonaccidental trauma has led to the gratuitous destruction of many families. Belated recognition of osteogenesis imperfecta and similar conditions resulted in restoring at least 65 children to families, without a single case being proved later of nonaccidental trauma (Paterson and McAllion, 1990).

In young children, rickets due to vitamin D deficiency causes progressive deformities, such as bowing of the femur, tibia, radius, and ulna; prominence of the costochondral junctions called *the rachitic rosary;* and indentation of the lower ribs at the point of diaphragmatic attachment (Harrison groove). Fractures like those typical for child abuse can occur; even in the skull, fracturelike appearances can occur (Paterson, 1981). Rickets can result from inadequate diet or sunshine, malabsorption, renal disease, abnormal calcium/vitamin D metabolism, or chronic phenobarbital or phenytoin treatment for seizures (Stewart and Rosenberg, 1996).

In adults, osteomalacia may present with diffuse bony pain and tenderness, loss of height due to vertebral compression fractures, and muscular weakness.

Scurvy can also cause an elevated periosteum and bony tenderness, as well as generalized osteopenia leading to fractures. While uncommon in affluent countries, vitamin C deficiency should be excluded in cases of suspected child abuse or shaken baby syndrome (Innes, 2006).

Bony deformities are also seen with congenital syphilis, prostaglandin E therapy, methotrexate, hypervitaminosis A, hereditary sensory neuropathy leading to frequent trauma (Stewart and Rosenberg, 1996), mucopolysaccharidoses, neurofibromatosis, and many other conditions.

The differential diagnosis of multiple fractures on a skeletal survey, in the absence of clinical signs of abusive injury, also includes radiologic misinterpretation of normal variants of ossification in the first year of life as metaphyseal fractures (Le Fanu, 2005).

Palpation

Palpate for areas of warmth (as may be found over the shins in Paget disease). Also palpate for tender areas (for example, tenderness over the neck of the fibula is a sign of a spiral fracture).

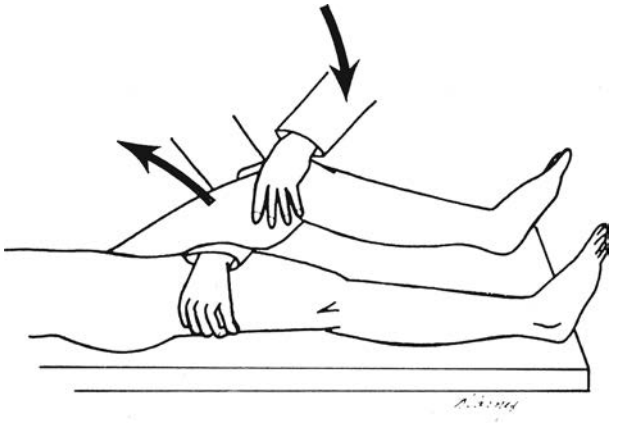


FIGURE 25-3 Stressing the femur. (From Dorman TA, Ravin TH. *Diagnosis and Injection Techniques in Orthopedic Medicine.* Baltimore, MD: Williams & Wilkins; 1991, with permission.)

Percussion

Percussion is performed with light finger pressure; pain may be a sign of osteomyelitis. (Rolling a pencil along a long bone, exerting pressure, is another way to elicit tenderness.)

Special Maneuvers

Stressing the Femur

Although radiography is the gold standard for diagnosing bony conditions, there are occasional false negatives for fractures because the fragments are nondisplaced and the lines of demarcation are blurred, as by a prosthesis from previous surgery. Owing to such difficulties, the incidence of delayed diagnosis of hip fractures ranges from 2% to 9% (File et al., 1998). In patients with pain on weight bearing or pain with certain movements but with negative radiographs, the maneuver shown in Fig. 25-3 may be tried. A thigh with an intact femur can withstand the examiner's entire weight without pain, but increasing the load in a patient with a nonintact femur will cause the patient to jump suddenly with pain.

Auscultatory Percussion

> *We find, for example, that among tissues of the body, bone is the best conductor of sound.* (Cammann and Clark, 1840)

A Method

To detect fractures of the femur or of the pubic rami, place your stethoscope at the symphysis pubis, and with the earpieces in your ears, percuss each patella in turn, taking care to strike the patella with exactly the same force on both sides (Carter, 1981).

On the side of the fracture (Fig. 25-4), the percussion note will be softer and missing some high-frequency components. Sound transmission gradually returns to normal as the fracture heals.

Caveats

1. This test assumes the presence of patellae, the absence of knee effusions, and the existence of a fracture on one side only (Peltier, 1958).

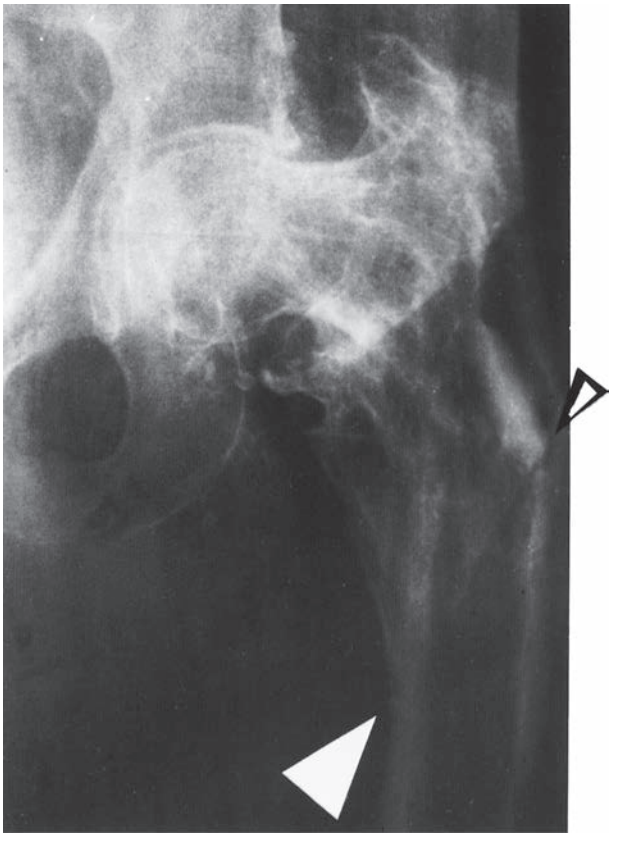


FIGURE 25-4 A patient had evidence of impaired auscultatory percussion in a hip fractured many years previously (with no recent trauma). Admission hip films now revealed no evidence of nonunion to at least two observers. On the insistence of the examiner who had noted the physical findings, another film was obtained. Note the new fracture line running about halfway from the *upper arrow* toward the *lower arrow*.

2. To avoid inducing false positives and false negatives, the patient's legs should be unencumbered by blankets or heavy dressings (Peltier, 1958). Both legs must be in the same position (i.e., symmetric—not with one hip or knee in flexion and the other in extension).
3. The test may also be positive in pseudoarthrosis (Berger, 1982), hip dislocation without fracture, unilateral bone cysts, and bone tumors (Sotos, 1982). However, it may miss hip effusion (Peltier, 1958), aseptic necrosis of the femoral head, and impacted fractures of the femoral head.

False Positives

Impaired transmission on the right in a patient whose right hip fracture was for years remote was caused by a prosthesis, which must have dampened the cortical bone vibrations. In a series of 41 consecutive patients presenting with hip trauma, of whom 19 had a fracture demonstrated radiographically, there was only one equivocal false positive in a patient with diffuse Paget disease (Adams and Yarnold, 1997).

False Negatives

Dr John Guarino finds that some fractures may be missed if the diaphragm is placed on the symphysis pubis; he places

the stethoscope head on the iliac crests (J. Guarino, *personal communication,* 1988).

A schizophrenic patient who was reputed to have a fracture on the right was shown to have impaired transmission on the left. On reviewing the radiographs, it was found that the patient had a congenitally dislocated hip on the left with a false acetabulum, in addition to the recent fracture on the right. The fractured side actually transmitted sound better than the dislocated side because the fractured femoral head was still in the normal acetabulum.

An Alternate Method

Some examiners apply a vibrating tuning fork to the medial femoral condyle on each side while listening over the symphysis pubis (File et al., 1998).

Other Applications

The same principle has also been applied to diagnose fractures of the pelvis, humerus, clavicle, or other bones (Berger, 1982). The conductive paths to detect various fractures are as follows: medial malleolus to subcutaneous medial tibia (tibia); lateral malleolus to fibula head (fibula); acromion to medial clavicle or sternum (clavicle); olecranon to acromion or sternum (humerus); and ulnar styloid to olecranon (ulna) (Siffert and Kaufman, 1996).

A Method for the Humerus. Place the bell of the stethoscope over the manubrium. Flex both elbows to 90 degrees and percuss the olecranon. In the event of a disruption in bony conduction, the affected side will be duller in pitch and intensity (Dorman and Ravin, 1991).

The "lost art" of auscultatory percussion is particularly useful in areas where radiographic facilities are limited. Additionally, because calcification detectable by radiography lags behind the restoration of bony continuity and a degree of strength, this technique possibly could serve as a guide to earlier rehabilitation and improved functional results. Metal plates and intramedullary devices alter sound transmission sufficiently to decrease the value of the method for internally fixed fractures (Siffert and Kaufman, 1996).

If a fracture is suspected on the basis of the clinical examination, but radiographs are negative, a computed tomography (CT) scan, a bone scan, or magnetic resonance imaging (MRI) may be indicated. MRI may show subtle changes in the marrow or soft tissue that are not evident on the CT scan (J. Dwyer, *personal communication,* 1999).

The Tensegrity Model

The structure of the body is formed by the endoskeleton along with fibrous connective tissues (fascia, ligaments, and tendons, along with the contractile elements called muscles). The term *tensegrity* refers to a three-dimensional structure based on envelopes and struts. The term was coined by the architect Buckminster Fuller in 1929, derived from the words tension and integrity. He discovered that it is possible to enclose large working spaces with light materials by replacing the conventional pillar, beam, and cantilever form of construction with an integrated one, most familiar in the form of a geodesic dome. Here, every component of the structure plays a role in its integrity. The interactive relationships of compression and tension throughout the system maintain form and, in the case of biologic structures, also function (T. Dorman, *personal communication,* 1999). The distribution of stresses within the system explains how injuries at one point produce symptoms at another, with consistent patterns of referred pain and tenderness. The concept of fault propagation—as in a snag to nylon stockings or a dent in the windshield—pertains. The interactions are very complex, and application to clinical medicine is largely empiric at present. This book can only hint at the possibilities and refer the student to works on orthopedic medicine for further study.

Except for bones, the moving parts are largely translucent to X-rays. Too much emphasis may be placed on radiographic findings such as calcifications that seldom cause pain themselves, to the exclusion of the functional physical examination.

Basic Principles of Examination

History

The examination of the patient with pain likely to be of musculoskeletal origin begins with a careful history of the distribution of symptoms, as with the pain diagram shown in Fig. 25-5. As in other areas of medicine, the history is the key to the diagnosis. The pain diagram may contribute 85% of the information needed by a skilled physician (T. Dorman, *personal communication,* 1998).

The distribution of dermatomes and peripheral nerves is shown in Fig. 25-6, but remember that there is substantial individual variability. Moreover, pain patterns do not necessarily follow the distribution expected on this basis. The physician may be forced into the Hippocratic mode of *listening to the patient* and learning to recognize patterns derived from clinical experience in addition to those from the neurophysiology laboratory.

In general, pain is referred only distally, although the knee and the elbow may refer pain in both directions. Referred pain can come from joint capsule, tendon, muscle, ligament, bursa, dura mater, or nerve sheath. Bone pain does not usually radiate.

"Pins and needles" sensations, in contrast, arise only from nervous system lesions. The lesion always lies proximal to the upper edge of the paresthetic area. If a nerve trunk is compressed proximally (as at the sciatic nerve or the brachial plexus), the sensations are a release phenomenon. However, with distal or, remarkably, nerve root compression, they are a pressure phenomenon. Paresthesias that ignore body segmentation are likely to be a sign of spinal cord compression (Cyriax, 1982).

The patient may experience referred pain as a "numblike" sensation (not associated with loss of sensation on testing), for which the term "nulliness" has been coined. Nulliness has been said to be characteristic of referred sensations from ligamentous injuries and specifically does not denote interruption of sensory pathways (Dorman and Ravin, 1991). The term is not in general use.

Physical Examination

The active and passive range of motion for each joint is determined, as described below. Then the limb is placed in a

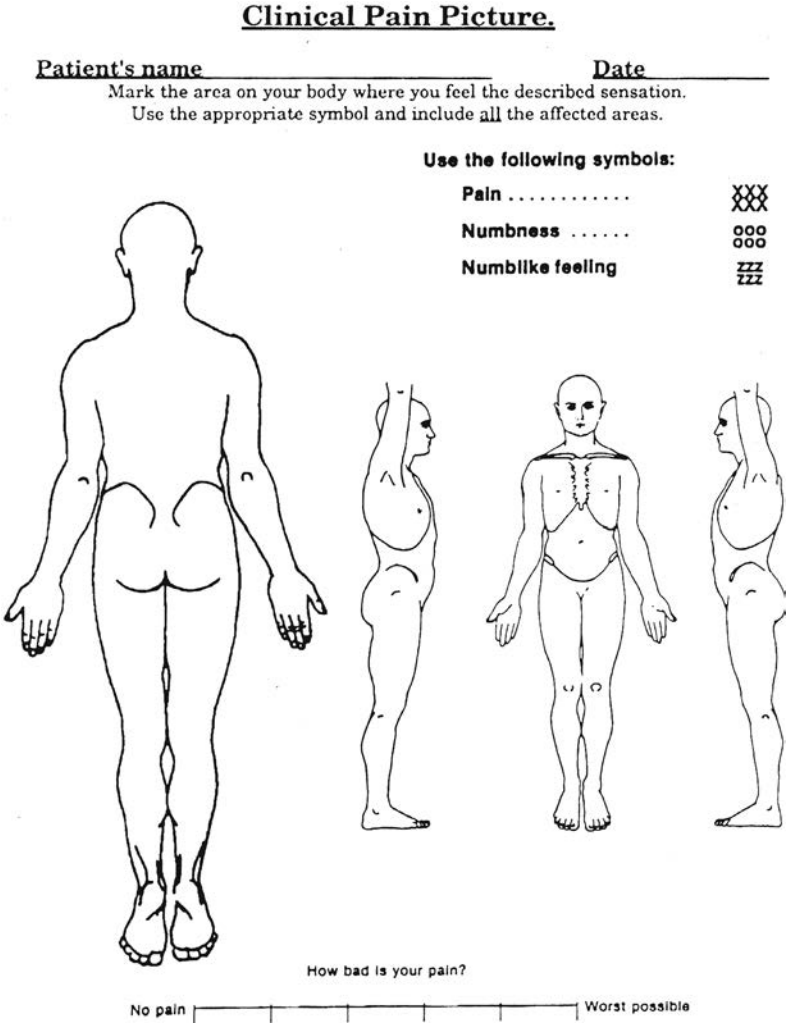


FIGURE 25-5 Clinical pain diagram. (Courtesy of Dr Thomas Dorman.)

position to test the contraction of each muscle, isolated as far as possible. Contraction against resistance tests muscle strength and also can help identify the source of tendon pain, as will be described in the examination of various joints.

Muscle Strength: Resistance Testing

Initially, one should test muscle strength in classmates and patients with no known muscle or neurologic disease. Because all these folks are presumably healthy, one is testing to become familiar with the routine and to learn the range of biologic variability. Also, one can become familiar with the sensation of uniform resistance that occurs when a muscle is overpowered.

Muscles that are truly weak usually give way smoothly when resistance is overcome. This is to be distinguished from voluntary release, which occurs in one of two ways: some will actively and successfully resist for a few moments and then suddenly let go, whereas others will attempt to simulate the gradual release of true weakness. Deliberate relaxation always produces a series of small "cogwheel" steps (Hall, 1983), to be distinguished from the cogwheel rigidity of Parkinson disease (see Chapter 26). The converse is not necessarily true; patients who are by other criteria judged to have a legitimate weakness may demonstrate this intermittent "give" (T. Dorman, *personal communication,* 1999).

Although establishing the patient's cooperation during the examination is important, the discovery of voluntary release does not necessarily guarantee that the disease is of the higher centers. Patients may feign gross weakness to ensure that the doctor will not overlook a minor degree of real muscle power loss (Hall, 1983). Also, voluntary release may occur because of pain.

Some General Principles

Muscles must be tested in such a way that the examiner's and the patient's strength are fairly evenly matched. When examining strong muscles, or patients stronger than yourself, it is important to give yourself every mechanical advantage, such as a long lever arm and placement of the patient's muscle at a mechanical disadvantage. The examiner may, if necessary, use his body weight in addition (Dorman and Ravin, 1991). Some muscles may have to be tested when fatigued by exercise (see item 11 below) or by means other than resistance testing. Otherwise, you are likely to miss relatively mild degrees of weakness, which can be of great diagnostic significance. Dr Michael Schlitt of Washington advises testing the left and right side simultaneously.

A grading scheme for muscle strength is given in Table 25.1.

In testing patients with neuromuscular disease, each pair of muscles should be scored individually. Especially in cases of

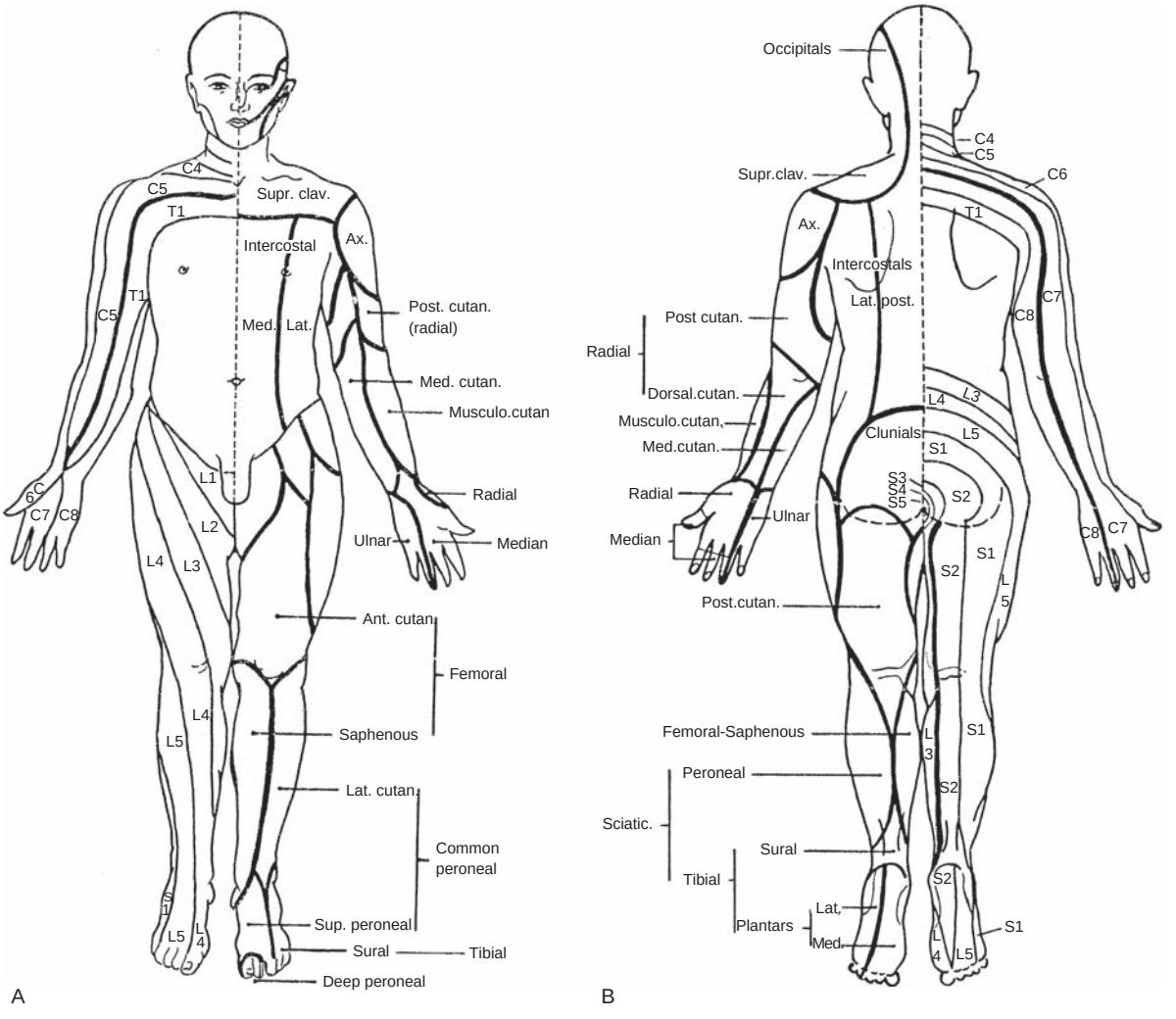


FIGURE **25-6** **A:** Sensory innervation of the anterior surface by nerve root (model's right) and peripheral nerve (model's left). **B:** Posterior view of same. These figures should not be taken as exact. There is substantial overlap and individual variation. The drawings also differ significantly when a different methodology is used for mapping (see Dorman and Ravin, 1991). A copy of this or a similar diagram is a useful part of your pocket notebook.

TABLE **25.1** *Muscle examination*

Grade			
%	No.	Letter	Key
100	5	N (Normal)	Complete range of motion against gravity with full resistance
75	4	G (Good)[a]	Complete range of motion against gravity with some resistance
50	3	F (Fair)[a]	Complete range of motion against gravity
25	2	P (Poor)[a]	Complete range of motion with gravity eliminated
10	1	T (Trace)	Evidence of slight contractility; no joint motion
0	0	0 (Zero)	No evidence of contractility
	S or SS		Spasm or severe spasm
	C or CC		Contracture or severe contracture

[a]Muscle spasm or contracture may limit range of motion. Place a question mark after grading a movement that is incomplete from this cause.

symmetric impairment, these operational definitions are very useful.

The interrater agreement on precise grade of muscle strength is between 48% and 75%; intrarater agreement is 54% to 65%. Allowing a difference of one grade, interrater agreement was 90% to 95% and intrarater agreement 96% to 98% (Iddings et al., 1961). Detailed guides to testing individual muscles have been compiled (Gray, 1966; Leopold, 1952; Medical Research Council, 1943; Vick, 1976) and are useful in certain settings. If you test the set given below, however, you are unlikely to miss a significant nerve root lesion. Selected peripheral nerve lesions are discussed at the end of this chapter.

Remember that *innervation is written in protoplasm,* not stone. No two authorities agree on all the branches of the nerves because there is a wide range of biologic variability. (Dr John Dwyer of Chicago suggests presenting this aphorism on a printed card "to all purists and most lawyers who try to browbeat people with anatomic charts as being 'authoritative'.")

1. Abduction at shoulder: Exert pressure on the lateral aspect of the resting upper arm, and tell the patient, "Push my hand up in the air as far as you can." This primarily tests the supraspinatus (C5). Stand in front of or at the back of the patient, placing one hand on his elbow and the other on the far side at his waist to provide counterpressure.
2. Flexion at elbow: Have the patient make a fist, with his elbow partly flexed and the palm pointing toward himself. Place your hand on his forearm (not his hand—you are trying to isolate muscles crossing the elbow joint, not the wrist) and offer a resistance to further flexion. Say, "Pull my hand against your shoulder."This primarily tests the brachioradialis (C6).
3. Extension at elbow: Position the patient's arm so that it is parallel to the ground to eliminate the effect of gravity. Starting from an angle of about 130 degrees, instruct the patient, "Push me away from you." This tests the triceps (C7). Extension at the wrist also primarily tests C7; have the patient keep the fingers extended.
4. Adduction of thumb: With the patient's thumb placed alongside the palmar aspect of the index finger, try to abduct his thumb, and say, "Keep it there." Alternately, have him try to retain a strip of paper between the thumb and index finger. This tests C8 and T1.
5. Palmar interossei: Instruct the patient to spread his fingers. Insert your own fingers into the interspaces and urge the patient to "Cut my fingers off, like with scissors." Do not allow the patient to flex his fingers during this maneuver. This checks C8 and T1.
6. Abductor digiti minimi: Have the patient extend his fingers and attempt to abduct the little finger against resistance. This primarily tests T1.
7. Hip flexion, abduction, and adduction: With the patient supine, and hip and knee flexed to about 80 degrees, have him pull his knee toward his trunk against resistance. This tests the iliopsoas and primarily L2 and L3. With the patient's legs extended, place your fist between his knees and ask him to press his legs together. This tests the adductors, the obturator nerve, and L2–L4. Hold his extended legs together at the ankles, and ask him to spread his knees apart. This tests the abductors (gluteus medius and minimus) and L4–S1. It is important to test girdle strength (hip flexion) because some myopathies preferentially afflict the proximal muscles while sparing the more easily tested distal muscle groups. Other good tests of the pelvic girdle are having the patient arise from the squatting position without the use of the hands, and the "timed stands" test (*vide supra*).
8. *Dorsiflexion of foot:* With the patient supine and his knee bent with heel on the examining table, ask him to dorsiflex his foot strongly and "keep it there." The examiner, using his full weight, should not normally be able to depress the foot. Minor degrees of weakness will not be detected unless the examiner uses his full power (Fig. 25-7). This maneuver tests the tibialis anterior, which is innervated by the deep peroneal nerve, primarily from L4. It is especially important because there is no conveniently testable reflex arc for L4 (T. Dorman, *personal communication,* 1999).
9. *Dorsiflexion (extension) of great toe:* Have the patient resist as you push down against his dorsiflexed big toe (Fig. 25-8). In this instance, the examiner is stronger than the patient. The extensor hallucis is innervated by the deep peroneal nerve, derived mostly from L5. A subtle weakness in the extensor hallucis longus is much more easily detectable than a slight weakness in a much larger muscle.
10. *Flexion and extension of knee:* With the patient prone, and the knee flexed to 90 degrees, instruct the patient, "bring your heel to your buttocks" as you push on his heel. Resisted flexion tests the hamstrings, branches of the sciatic nerve, and primarily S1 and S2. (The examiner is stronger than the patient in this maneuver.) Then, place your hand on the anterior side of the ankle and ask the patient to push against you. Compare the two sides: the patient should be stronger than the examiner. This tests the quadriceps femoris, the femoral nerve, and primarily L3.

    This maneuver puts a stretch on the third lumbar root. Note that prone-lying knee flexion is to L3 what straight-leg raising (*vide infra*) is to the four roots below (Cyriax, 1982).

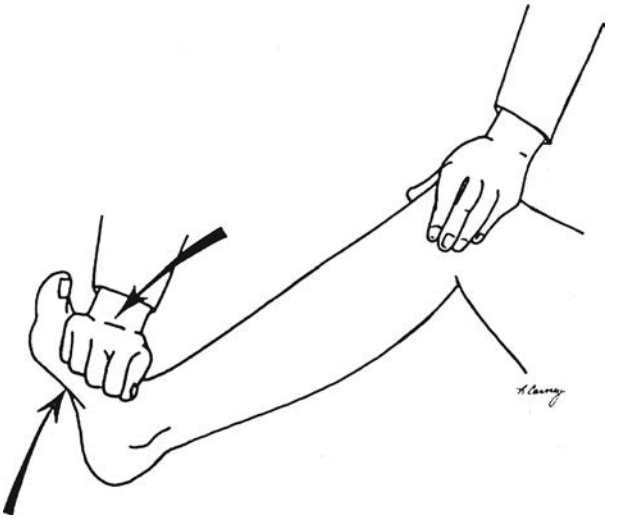


Figure 25-7 Examination of tibialis anterior. (From Dorman TA, Ravin TH. *Diagnosis and Injection Techniques in Orthopedic Medicine.* Baltimore, MD: Williams & Wilkins; 1991, with permission.)

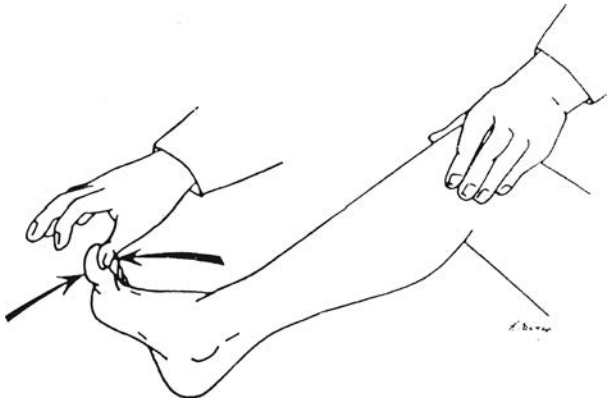


FIGURE 25-8 Weakness of extensor hallucis is an early sign of an L4–L5 root lesion. (From Dorman TA, Ravin TH. *Diagnosis and Injection Techniques in Orthopedic Medicine*. Baltimore, MD: Williams & Wilkins; 1991, with permission.)

While the patient is prone, check for wasting or swelling in the buttocks. Ask the patient to contract the glutei and compare the bulk on the two sides. Also check for symmetry of the gluteal folds.

The ankle jerks are also best tested in the prone position (see Chapter 26).

11. *Plantar flexion of the foot:* This function is best tested with the patient standing. It may be helpful to have the patient perform ten toe raises on both feet and ten more on each foot separately. This fatigues the calf muscles and accentuates minimal differences in strength (Hall, 1983). One-legged toe stands test S1 primarily; L5 and S2 are involved to some extent. To test the soleus (always S1), one must put the gastrocnemius muscle out of action by flexing the knee to 90 degrees and then having the patient perform plantar flexion against your hand's resistance.

Subtle S1 weakness can also be sought by checking flexor hallucis longus. Ask the patient to claw his toes against resistance and note any asymmetry (Dorman and Ravin, 1991).

The Axial Skeleton

The Cervical Spine

Range of Motion

First, check the active range of motion to assess patient cooperation and the spontaneous range. Then, check the passive range.

The neck has six motions: flexion (normally the chin reaches manubrium); extension (normally face is parallel to the ceiling); rotation (normally 90 degrees in each direction); and side bending (normally possible to 45 degrees in each direction). Note how many fingers fit between the patient's chin and manubrium and the number of degrees lacking from the normal range in each direction. These observations are required in most legal and disability reports.

Disc Disease

Most neck surgery in the US is performed because of root impingement due to intervertebral disc herniation. The importance of disc disease may be overemphasized because sophisticated imaging procedures make it so easy to demonstrate, showing many disc protrusions with nerve root impingement that in the days of myelography might have remained undemonstrated, whereas the neurologic deficits cleared on expectant management over a period of several months. Repeated meticulous neurologic examinations are of utmost importance in advising the patient.

A summary of the findings with root compression at various levels is summarized in Table 25.2. Reflex testing is described in Chapter 26.

An old test called the *neck compression test* or *Spurling*[1] *maneuver* was said to be 100% sensitive and "almost pathognomonic" for the diagnosis of lateral rupture of a cervical intervertebral disc, at least for those that could be diagnosed in 1944 (Spurling and Scoville, 1944). To perform the test, extend the neck, rotate the head and neck toward the symptomatic side, and exert downward pressure on the top of the head. A positive test is reproduction or accentuation of the (radicular and chronic) neck, shoulder, arm, and hand pain. The mechanism is that neck extension causes posterior disk bulging, and lateral flexion and rotation narrow the ipsilateral neural foramina. Have the patient extend the neck actively, to use careful compression, and stop when radiating pain or numbness is produced. In the 1990s, sensitivity of the test was said to be "low," but when positive, it was said to be helpful in localizing the problem to the cervical spine (Ellenberg et al., 1994). False positives may occur in ligamentous injuries.

Diseases of Vertebral Bodies

The vertebral bodies are subject to diseases that affect other bones, including osteomalacia, osteoporosis, hyperparathyroidism, primary or metastatic malignancies, tuberculosis and other infections, and multiple myeloma. In such conditions, there will often be tenderness to pressure or percussion over the dorsal vertebral spine.

Whiplash

Neck injury from vehicular collisions is a common and vexing problem, which increased in frequency since the enactment of mandatory seatbelt laws.

In the acute setting, it is critical to stabilize the neck with a rigid collar and transport the patient on a spine board. Perform a neurologic examination and rule out fracture or dislocation with radiographs (including CT scan in questionable cases) before moving the neck. A normal neurologic examination does not rule out a significant bony injury that can cause severe spinal cord injury.

Whiplash (sudden forceful extension flexion of the neck) causes ligamentous injury, which is very difficult to document objectively. Severity depends on a number of factors; the severity of injury may be disproportionate to the apparent seriousness of the accident. Maximal neck injury occurs at a change in velocity of about 11 to 15 m per second because this coincides with the duration of the reflex arc (80 to 100 milliseconds). Injuries from unanticipated (rear end) collisions are likely to be more severe (Dorman, 1997).

[1]This test is named for R.G. Spurling, who also treated General George S. Patton after his untimely accident that resulted in a fractured neck and quadriplegia (M. Faria, *personal communication,* 1988).

TABLE **25.2** *Symptoms and signs in nerve root lesions*

Root	Pattern of referred pain; Sensory symptoms	Weakness	Reflex changes	Comments
C1	Vertex of skull	Rotation of neck		Extrasegmental reference from dura mater occurs with cervical disc lesions
C2	Temple, forehead, behind eyes	Shrugging shoulders		
C3	Paresthesias, numbness lower pinna, cheek, temple	Shrugging shoulders (probably undetectable)		Rarely affected
C4	Midneck to shoulder; band of cutaneous analgesia may be present along spine of the scapula	Probably not detectable		Rarely affected
C5	Scapular area to front of arm and forearm to radial side of hand; thumb not involved	Infraspinatus, supraspinatus, deltoid, biceps (resisted abduction weak)	Biceps sluggish; brachioradialis sluggish, absent, or inverted	May be confused with (or accompanied by) shoulder problems
C6	Front of arm and forearm to radial side of hand; paresthesias, cutaneous analgesia may affect thumb and index finger	Biceps, brachioradialis, supinator brevis, extensor carpi radialis	Biceps jerk sluggish, absent, or inverted	Patient may awaken with a painless drop wrist
C7	Scapular area down back of arm, outer forearm to fingertips; cutaneous analgesia or paresthesia may be present in index, long, ring fingers	Triceps, radial flexor, sometimes wrist extensors	Triceps jerk (a C7 reflex) [may not be affected even when triceps muscle extremely weak (Cyriax, 1982)]; thumb reflex may be altered; finger flexion reflex may be altered pectoral; may have relief	Most common root lesion (70%); pain may be from placing hand on top of head
C8	Lower scapular region, back or inner side of arm, inner forearm; paresthesia may be present in fifth finger	Ulnar deviators of wrist, extensor and adductor of thumb, extensors of fingers; abductor indicis		Differential diagnosis includes Pancoast tumor, cervical rib, angina pectoris
T1	Lower pectoroscapular area	Abductor digiti minimi; in disc lesions, there is no weakness in the hand		Very rare; cervical rib or neoplasm more likely
L1	Region above trochanter, groin; possibly cutaneous analgesia near inner half of inguinal ligament	No weakness	No deep tendon reflex changes; cremasteric reflex may be lost	Very rare
L2	Upper lumbar pain to front of thigh as far as knee, with prolonged standing; cutaneous analgesia from groin to patella	Iliopsoas; hip adductors	No deep tendon reflex changes	Most common cause is arthrodesis at a lower level; consider metastases, especially if bilateral
L3	Midlumbar, upper buttock, groin, anteromedial thigh and knee, ends above ankle; numbness at inner knee or inner leg	Iliopsoas, quadriceps, hip adductors	Sluggish or absent knee jerk	4%–8% of disc lesions

(continued)

TABLE **25.2** *Symptoms and signs in nerve root lesions (continued)*

Root	Pattern of referred pain; Sensory symptoms	Weakness	Reflex changes	Comments
L4	Midlumbar, inner quadrant of buttock, lateral aspect of thigh, anterior shin, crossing over dorsum of foot to big toe, cutaneous analgesia at medial side of foot and big toe	Tibialis anterior and extensor hallucis, hip adductors	Unaffected knee and ankle jerk; extensor reflex from big toe absent	60% of patients with disc lesions; about 15% have both an L4 and L5 lesion (Cyriax, 1982)
L5	Cutaneous analgesia at outer leg and inner three toes; all toes may be involved	Extensor hallucis tibialis posterior, peroneals, gluteus medius, biceps femoris, lateral hamstrings, hip abductors	Sluggish or absent ankle jerk	About 43% of disc protrusions occur at L5, but the fifth root can also be compressed by a disc protrusion at L4, and an L5 protrusion can cause an S1 palsy
S1	Cutaneous analgesia at lateral knee, outer leg, outer foot, and outer two toes; all toes may be involved	Calf muscles (plantar flexors of ankle), peroneals, flexor hallucis longus; lateral hamstrings and biceps femoris; gluteal mass wasted and patient cannot contract it	Depressed or absent ankle jerk	
S2	Numblike sensation common in posterior thigh, calf, and heel	Plantar flexors of ankle; medial hamstrings; findings similar to S1 except peroneals spared		
S3	Pain in groin, down inner aspect of thigh to knee; can also cause pain in saddle area	No detectable palsy	Bulbocavernosus and anal reflexes may be abolished in lesions of lower sacral segments	
S4	Pain in saddle area; paresthesias in genitals	Weakness in bladder or rectum		

With whiplash, there may be a postconcussion syndrome (such as dizziness), but neck pain has a delayed onset. This is a hallmark of ligamentous injury anywhere in the body. The further the cephalad, the greater the delay because pain is exacerbated by edema, and edema fluid accumulates downhill. Persons with whiplash often experience ligamentous injury at the other end of the spinal column as well.

A wide variety of symptoms and signs have been described in whiplash, including blurred vision, ciliary spasm, mydriasis, vertigo, dysphagia, loss of balance, and forgetfulness. Sometimes the patient responds to treatment of the ligamentous injury. The mechanism is not well understood (Dorman and Ravin, 1991). Neural injury, however, is likely in many cases. Hemorrhages and histologically verified lesions of the brainstem (Unterharnscheidt, 1986) have been reported. A sixfold increase in the permeability of the blood–brain barrier was produced by experimental whiplash in rhesus monkeys (Domer et al., 1979). An injury to the intervertebral disc could lead to the release of inflammatory mediators (Pettersson and Toolanen, 1998). Fibrocartilaginous embolism to the spinal cord and brain has been documented as a consequence of nucleus pulposus injury (Toro et al., 1994; Tosi et al., 1996; Toro-Gonzalez et al., 1993). A form of hypothyroidism has also been described following whiplash injury (Sehnert and Croft, 1996).

There has been speculation for many years that multiple sclerosis (MS) might be provoked by trauma. One suggestive case report, of a police officer seeking compensation because he developed symptoms of MS soon after a whiplash injury, was heard on appeal in the British House of Lords in 2000 (*Dingley vs. Chief Constable of Strathclyde Police*). After hearing testimonies

from opposing teams of neurologists, the noble Lords determined that trauma does not provoke MS. They noted, however, that an acceptable theory to explain what it is that overcomes the blood–brain barrier and permits the development of symptomatic MS would have gone a long way toward supporting the appellant's case (House of Lords, 2000). Some have hypothesized that fibrocartilaginous embolism or fat embolism (see Chapter 26) could be that mechanism. Being more likely to cause arterial occlusion, the former is more likely to be associated with frank infarcts, as in the transverse myelitis that can be one presentation of MS. The trauma need not be severe; cases have seemingly been precipitated by falls or even by performance of handstands or somersaults (Tosi et al., 1996).

Most automobile collisions do not produce the high rotational velocities and accelerations needed to shear cortical veins where they enter the dural sinuses, but occasionally, subdural hematomas can occur. This rare consequence might be kept in mind if symptoms do not subside. One case was reported as a result of riding the bobsled at Disneyland; the patient was on heparin (Ommaya and Yarnell, 1969).

One clear lesson for today's student is that patients who sustain a whiplash injury or other "minor" trauma should not be dismissed out of hand as malingerers.

Torticollis

An asymmetric posture of the neck (torticollis) may have many causes, including prolonged strained positioning as during sleep (Dorman and Ravin, 1991). Because this posture so often results from dystonia, it is discussed in Chapter 26.

Atlantoaxial Joint

The atlantoaxial joint is especially worthy of attention because subluxation threatens the spinal cord. It should be carefully examined radiographically in trauma patients, with open-mouth views to check for fracture of the odontoid process.

Instability of the upper cervical spine, with atlantodental or atlantoaxial subluxation, is very common in rheumatoid arthritis. Symptoms and signs include "headache" in the occipital region and upper neck and an irreducible lateral head tilt. Hand clumsiness may signify myelopathy, not simply peripheral arthritis. Deforming arthritis may make evaluation of reflexes and other neurologic signs difficult (K. Smith, *personal communication*, 2009). Symptoms and signs are poorly correlated with the severity of the instability or myelopathy (Nguyen et al., 2004; Arlt and Steinmetz, 2004); indeed, typical symptoms may be absent (Cakir et al., 2008). Cranial nerve impairments, primarily of IX, X, and XI (see Chapter 26), suggest brainstem compression. The consequences of missing the diagnosis include quadriplegia or sudden death. This is one instance in which early and periodic radiologic evaluation is warranted, even in the absence of clear clinical indications, other than the diagnosis of rheumatoid arthritis. Cervical spine involvement occurs in more than half of the patients with this diagnosis (Bouchaud-Chabot and Lioté, 2002).

Cervical Spondylosis

Ligament and fascia attenuations leading to and associated with degeneration of the intervertebral joints, the zygoapophyseal joints, and the uncovertebral joints of Luschka, with their radiologic manifestations, are grouped together as cervical spondylosis. Severe narrowing of the spinal canal can damage the cord—cervical spondylitic myelopathy. The differential diagnosis includes cervical disc disease (Dorman and Ravin, 1991).

Diagnosis and treatment of specific aspects of cervical spondylosis are generally not considered in American medical schools. However, for those with an interest in orthopedic medicine, it is worth noting that there are patterns of radiated pain believed to be characteristic of injury to various myofascial attachments to bone (Fig. 25-9).

Thoracic and Lumbosacral Spine

Inspection

The curvature of the spine is normally concave forward (kyphotic) in the thoracic and sacral regions, and convex forward (lordotic) in the lumbar and cervical regions.

Kyphosis

In adolescents, an exaggeration of the normal thoracic kyphosis can result from Scheuermann disease, vertebral osteochondritis, lateral malcurvature (scoliosis, *vide infra*), or just bad posture. Pathologic kyphosis may also accompany rickets. In older women, the so-called dowager's hump may result from osteoporosis. A more angular deformity (in contrast to a gentle curve), called a *gibbus,* should suggest tuberculosis of the spine (Pott disease) or metastatic carcinoma (Fig. 25-10).

Lordosis

An exaggerated lordosis can be primary (as in rickets, cretinism, or spondylolisthesis), but is usually compensatory for other deformities of the spine or diseases in the lower limbs (e.g., flexion contracture of the hip, congenital dislocation of the hip, progressive muscular dystrophy, paralysis from poliomyelitis, obesity of the abdomen, dorsal kyphosis, and shortening of the Achilles tendons [Raney and Brashear, 1971]). Most commonly, an increase in lordosis results from poor posture, pregnancy, or wearing high heels. Flattening of the lumbar lordosis may occur in painful conditions of the lower back such as sacroiliitis or a herniated intervertebral disc.

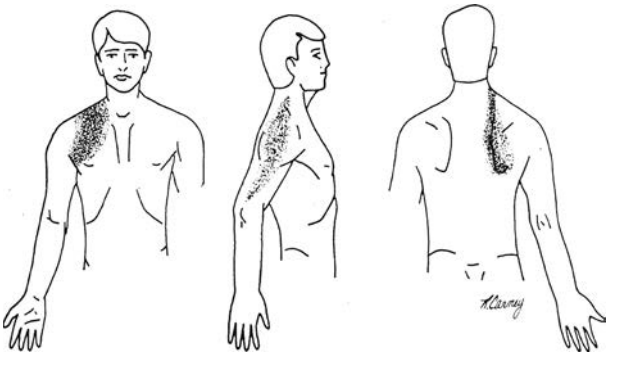


Figure 25-9 Myofascial attachments to bone have characteristic patterns of referred pain when injured. Patterns shown here are attributed to the tip, front, and back of the transverse process of C7. (From Dorman TA, Ravin TH. *Diagnosis and Injection Techniques in Orthopedic Medicine*. Baltimore, MD: Williams & Wilkins; 1991, with permission.)

FIGURE 25-10 A gibbus. This deformity is most likely caused by tuberculosis. However, a case could be made for "gargoylism" (i.e., Hurler or Morquio–Brailsford types of mucopolysaccharidosis). (The ornamental figure, from a second or third century pre-Columbian vessel from Colima, Mexico, is displayed in the Baltimore Museum of Art.)

Scoliosis

Scoliosis is a lateral curvature of the spine that usually becomes apparent during the years of growth. If neglected, it can progress to cause severe deformity and impairment in respiratory mechanics. Therefore, a check for this condition is part of the screening physical examination of children and adolescents.

The curve may either be S-shaped or C-shaped. The former is more likely to be structural, and the latter to result from a paralytic condition.

Look for a high shoulder, a prominent hip, or a projecting shoulder blade. Have the patient lean forward as you observe from behind, with his shoulder blades at your eye level. Look for asymmetry in the scapulae and the erector spini muscle masses.

Structural scoliosis may be congenital, resulting from developmental errors such as a hemivertebra or asymmetric fusion of two or more vertebrae. Cryptogenic scoliosis might result from a slight unilateral weakness of the trunk musculature or asymmetric growth at the epiphyseal plates of the vertebral bodies. Known causes of structural scoliosis include neurofibromatosis, osteogenesis imperfecta, osteomalacia, or unilateral thoracic conditions such as chronic empyema. Paralytic scoliosis may be a sequela of poliomyelitis, progressive muscular dystrophy, Friedrich ataxia, or syringomyelia. Compensatory scoliosis is the result of muscle spasm and/or pain in the spine or its associated soft tissues.

Palpation and Percussion

Palpation of spinous processes, at first gently and then more firmly, may reveal local tenderness due to fracture or infection. A shelflike step off may be felt in spondylolisthesis.

In a sophisticated orthopedic medical evaluation, tenderness in areas hypothesized to be the cause of problems on the basis of the clinical presentation is sought with the patient prone or during portions of the range of motion examination. A detailed consideration is beyond the scope of this text (Dorman and Ravin, 1991).

A Note on Fibrositis or Fibromyalgia

Patients with a variety of diffuse and recalcitrant complaints, including fatigue and pains, may be found to have a fairly consistent constellation of "trigger points" on palpation. This constitutes a syndrome, not a diagnosis. The concept has proved to be enduring, despite skeptics who consider trigger points to represent referred tenderness (Cyriax, 1982) from specific fascioligamentous disorders. The American College of Rheumatology has defined 18 specific "tender points." Pain at these points but not in other areas, with the exertion of 4 kg of force, is consistent with a diagnosis of fibromyalgia. A device called a *dolorimeter* has been devised to exert the correct amount of force, as pressing too hard at these points can cause pain in anyone.

Range of Motion

The patient should be undressed for the examination except for underpants and a brassiere in women. The patient may be allowed to wear a gown that opens in the back, or a toga made of a sheet passing through one axilla and pinned at the opposite shoulder and, if warranted, at the waist. Have the patient stand with feet together and his back to the examiner. (Keeping the feet together during the examination of the low back causes more of the movement to occur at the low lumbar spine and lumbosacral junction and less at the hip joints.) Ascertain whether the iliac crests are level and whether the patient is supporting his body weight equally on both legs.

When the patient is standing as straight as possible, check for extension by having the patient lean backward. Then check side bending to either side, noting both the range and the smoothness of an imaginary curve drawn along the spinous processes. The range can be described as the angle made with the horizontal by an imaginary line across the shoulders at the end of the movement. Standing the patient in front of a mirror helps in making the comparison. The examiner may find it advantageous to sit about 8 ft from the patient in making his observations.

Asymmetry in side bending may be caused by an anatomically short leg. If that is apparent, the pelvis can be leveled by elevating the appropriate heel for the remainder of the examination.

Next, examine rotation by having the patient fold his arms across the front of the chest with knees straight and feet together. Ask the patient to turn around and face you, first in one direction, then the other, and assess how much of the chest comes into view.

Last, examine flexion by asking the patient to touch his toes. Watch the curvature of the spine, of the paraspinous muscles bilaterally, and also watch the motion of the skin over the muscles in the buttocks. (Ask the patient's permission to lower his underwear sufficiently to make this observation.)

During the examination, ask neutral questions, such as "How is this for you?" Do not give a clue as to what is expected.

Typical findings on forward flexion in ankylosing spondylitis are shown in Fig. 25-11.

When there is a problem with the sacroiliac joints, it is usual to find that limitation of side bending to one side is associated with limitation of rotation to the same side. If a patient has the limitation of rotation to the other side, it may signify an abnormality in either hip (Dorman and Ravin, 1991). Other possibilities include a sprain in the iliolumbar ligament or an anomaly of the lumbosacral bony architecture.

The Sacroiliac Joint

The unique anatomic arrangements of the human pelvis are an essential adaptation for bipedal locomotion. A key feature is the sacroiliac joints, which permit slight toggling during walking but maintain stability by force closure of the irregular surfaces of the joint. When the joint is at the limit of its small range of motion, no great force is needed to damage its ligaments, permitting excessive movements to be transmitted to the three-joint complex of intervertebral disc and zygoapophyseal joints, and torsional stresses to the lumbar vertebrae and sacrum (Vleeming et al., 1990a,b; Ongley et al., 1987).

It is stated that asymmetric entrapment of the sacrum between the ilia causes many of the fascioligamentous sources of back pain.

To understand the mechanical effect of asymmetric sacroiliac joint movement, it is helpful to visualize the differential of a car. As the upper end of each femur lies in a plane anterior to the center of the sacroiliac joints, a forward and downward rotation of one ilium will tend to make the ipsilateral leg appear longer. The bedside demonstration of apparent leg-length discrepancy, therefore, can be taken as an indication of differential movement in the sacroiliac joints.

A Method for Demonstrating Pseudo–Leg-Length Discrepancy

1. Stress the pelvic ring by having the patient do several sit-ups.

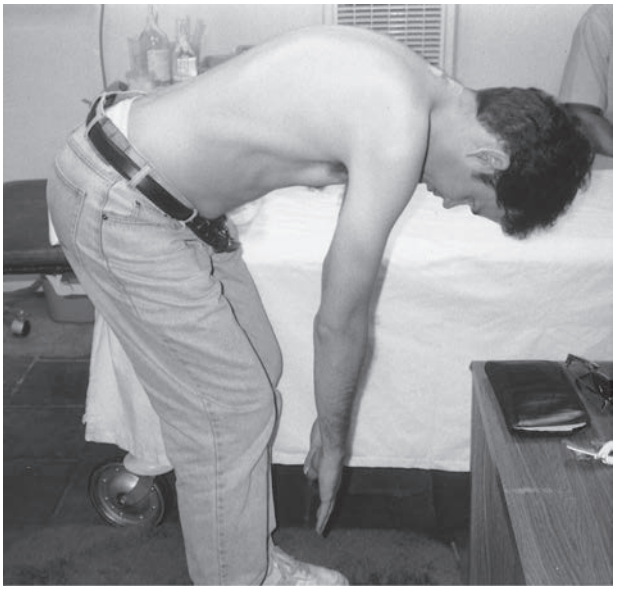


Figure 25-11 A patient with ankylosing spondylitis. Note the absence of lumbar and cervical lordosis, and the kyphosis in the thoracic spine.

2. Place your thumbs on or below the medial malleoli and apply slight even traction.
3. Compare the motion of the two thumbs as the patient sits and lies down. Look for a *change* in the relative position of the medial malleoli between sitting and lying (Dorman and Ravin, 1991).

Tenderness over the Sacroiliac Joint

It is possible to elicit tenderness over the sacroiliac joint with firm pressure even though it is covered by the overhang of the ilium; tenderness in the superficial ligaments may indicate an underlying problem in the joint (T. Dorman, *personal communication,* 1999). However, tenderness attributed to the sacroiliac joint can be referred tenderness, as from a lumbar disc lesion, or tenderness in the upper sacral extent of the sacrospinalis muscle (Cyriax, 1982).

Other Tests of the Sacroiliac Joint

Have the patient squeeze the examiner's hand between his knees, exerting a distraction force at the sacroiliac joints and pubic symphysis, which stretches the anterior sacroiliac ligament.

A number of other tests have been described and have also been shown to have moderate interobserver reliability. However, sensitivity and specificity have not been validated in appropriate studies for any of the tests (Laslett, 1997).

Stretch Signs

The Lasègue Sign or the Straight-Leg Raising Test

The history of the Lasègue sign and the use of stretch signs in diagnosing meningitis are discussed in Chapter 26.

A Method (after Bailey and Cyriax)

1. With the patient supine, place your hand beneath the lumbar spine to be sure there is no compensatory lordosis. Also, observe it during the test because a change in the lumbar curve invalidates the test result. In addition, the pelvis must not be allowed to rise from the table; the help of an assistant may be required.
2. Grasp the ankle of the leg to be tested (start with the painless side), and place your other hand on the front of the thigh to keep the knee extended. Slowly raise the leg until the patient experiences pain or maximal flexion has been achieved (at 60 to 120 degrees).
3. If the test produces pain, note whether the end-feel is abrupt or gradual. If it is gradual, continue gently as long as the pain is slight so as not to miss a painful arc, beyond which motion can continue without pain.
4. With the leg held at the point where pain just begins, have the patient flex his neck, keeping his trunk still. Note whether the pain is increased. Some advise dorsiflexion of the foot; Cyriax states that the latter maneuver provides no useful information.

Interpretation. Straight-leg raising, properly performed as above in a patient without limitations due to hip disease, tests the mobility of the dura mater from the L4 downward, the mobility of the L4 and L5 nerve roots, and the intraspinal extent of S1 and S2 nerve roots. The inclusion of step 4 is said to ensure specificity to the dura mater continuous with the sciatic nerve trunk and to eliminate possible confusion with strain of zygoapophyseal joints or ligaments

(Cyriax, 1982), although others state that limited straight-leg raising can result from strains of the sacrotuberous or sacrospinous ligaments (Dorman and Ravin, 1991).

The differential diagnosis of a positive straight-leg raising test includes disc protrusion impinging on nerve roots below the L4 level; meningismus; any intraspinal lesion such as a tumor below the L4 level; malignant disease or osteomyelitis of the ilium or upper femur; ankylosing spondylitis; fractured sacrum; ischiorectal abscess; hematoma in the hamstrings; or tight hamstrings resulting from a short leg or sacroiliac displacements (Cyriax, 1982; Dorman and Ravin, 1991). Straight-leg raising is not a test for "sciatica," which is a term referring to pain in the back, buttock, and leg—not a diagnosis.

Full, painless straight-leg raising does not exclude a disc lesion. A painful arc suggests a protrusion so small that the nerve root merely catches against it and slips over.

A Modified Test. In case of suspected partial sciatic nerve entrapment by the piriformis muscle, it may be helpful to perform the straight-leg raising test with the hip laterally (externally) rotated (and the piriformis muscle relaxed) and then, after replacing the leg on the couch, repeat it in full medial (internal) rotation. A reduction in the level of elevation favors the diagnosis of piriformis syndrome. Tenderness is also expected in the sciatic notch over the piriformis muscle, which may feel like a sausage (Dorman and Ravin, 1991).

Tests for "Impaired Patient Cooperation." If the range of straight-leg raising is limited, then the range of flexion of the outstretched leg on the trunk must be restricted to an equal degree. Inconsistency, perhaps uncovered by extending the legs of the seated patient in the guise of checking the Babinski sign, is a common finding in psychoneurosis and malingering. However, the converse does not hold. Trunk flexion may be more limited than straight-leg raising because in the latter case, the compression due to body weight is relieved and the disc protrusion may diminish (Cyriax, 1982).

The Magnuson test is a low-back gambit from Bailey (Clain, 1973). Mark the site that the patient indicates as the site of his pain. (I like to use chalk dust. A felt-tipped marker can cool the skin and so be a reminder for the patient as well as the examiner.) After rectal examination, or checking the reflexes, or some other activity, the patient is asked to indicate the site of pain again, as if the examiner were confused and wished to double-check himself.[2] Another method is simply to compare the pain diagrams prepared at different times; however, remember that sometimes the pain does change.

The Femoral Nerve Traction Test

Tension may be placed on the third and fourth lumbar roots by the maneuver described in item 10 in the section on testing "Muscle Strength." The sign is, however, far less constant than straight-leg raising. Generally, a positive sign consists of pain rather than limited range, with the attendant difficulties in interpretation.

Neurologic Signs

Signs of nerve root compromise are sought by testing muscle strength (*vide supra*) and reflexes (see Chapter 26). Key findings are summarized in Table 25.2.

Diagnostic Considerations

For a general physician, the first step in caring for a patient with neck or back pain is to check for neurologic compromise, and then for possible medical causes such as neoplasia or infection.

In one estimate, about 5% of all episodes of acute back pain are occasioned by a disc protrusion that compresses a sensitive part (T. Dorman, *personal communication,* 1999). Others estimate the proportion to be much higher. Neurosurgical intervention may be advisable.

Patients often seek relief through manipulative or other physical means. Any suggestion that the fourth sacral root is menaced by a disc protrusion is an absolute contraindication to manipulation by any method, and even traction is not wholly safe (Cyriax, 1982).

Ankylosing spondylitis is a consideration in young persons who experience early, insidious onset of chronic low-back pain. Frequently, the pain radiates to the buttock or down the posterior thigh, alternating from one side to the other. Radiologically, the disease begins at the sacroiliac joints, but clinical signs precede the radiographic ones by several years. Sometimes, the first sign is limited chest expansion. The progressive loss of spinal mobility may be monitored by the occiput-to-wall distance: the patient places his heels against a wall and attempts to place his head on the wall (Arnett, 1997). The HLA-B27 (human lymphocyte antigen) is found in 90% of cases overall, but only in 50% of American blacks with this diagnosis. Diagnostic criteria are given in Table 25.3.

An account of a variety of ligamentous strains that have been described and the maneuvers to demonstrate them is beyond the scope of this text.

TABLE **25-3** *Criteria for diagnosing ankylosing spondylitis: Modified New York Criteria, 1984*

1. Low-back pain of at least 3 months' duration improved by exercise and not relieved by rest
2. Limitation of lumbar spine mobility in sagittal and frontal plane
3. Chest expansion decreased relative to normal values for age and sex (previously, 2.5 cm or less measured at the level of the fourth intercostal space, with normal being >5 cm)
4. Bilateral sacroiliitis grade 2–4
5. Unilateral sacroiliitis grade 3–4

Definite ankylosing spondylitis: criterion 4 or 5 plus any clinical criterion.
From van der Linden S. Evaluation of diagnostic criteria for ankylosing spondylitis: A proposal for modification of the New York criteria. *Arthritis Rheum.* 1984;27:361–368, with permission.

[2] This demonstrates the truth of the old saying. "Liars ought to have good memories," attributed to Algernon Sidney in 1698. This worthy apparently got it from Corneille (La Menteur, Act IV, Scene 5, 1642), who must have been familiar with Montaigne's reference in his chapter on liars. The latter in turn was supposedly familiar with Quintilian's "mendacem memorem esse oportere." A Greek reference would convince me that they were all plagiarists, whereas a Sumerian one would suggest the existence of a universal truth.

The Appendicular Skeleton: Joints and Associated Parts

Overview on Examining Joints

In general, joints are checked for erythema (rubor), swelling (tumor), heat (calor), deformity, and crepitus. Crepitus indicates the state of the gliding surfaces. Fine crepitus indicates minor roughening of the joint surfaces; coarse crepitus indicates considerable superficial fragmentation of cartilage; intermittent creaking of bone on bone indicates the complete erosion of articular cartilage.

The most important condition to rule out in a patient presenting with an acute monoarticular arthritis is septic arthritis, as this can destroy cartilage within days, or even prove fatal. The only findings to occur in more than 50% of patients with septic arthritis, in studies involving 6,242 patients, were joint pain (sensitivity 85%), a history of joint swelling (sensitivity 78%), and fever (sensitivity 57%). Risk factors include age, diabetes mellitus, rheumatoid arthritis, joint surgery including prostheses, skin infection, and AIDS. Diagnosis requires examination of synovial fluid. The differential diagnosis of monoarticular arthritis also includes rheumatoid arthritis, gout, pseudogout, sickle cell disease, hemarthrosis, neuropathic arthropathy, osteoarthritis, and injury (Margaretten et al., 2007). Having considered the diagnosis of septic arthritis, proceed the rest of the examination.

Checking for tenderness (dolor) can provide much misinformation. It is better to identify the tissue at fault by testing the function. Details pertinent to individual joints are discussed below in the sections on the regional examination.

The joints should be put through their range of motion both actively and passively. The active movements show the patient's willingness to perform the requested movements and quickly indicate which motions to test in detail.

If the patient has less than a full range of motion, the angle through which the joint moves should be measured. A simple device called a *goniometer* (basically, a jointed plastic stick attached to a protractor) is available for this purpose or can be improvised. Special features important in the range of motion examination of a particular joint are discussed when that joint is separately considered below. Always compare the two sides.

Each primary motion of the joint must be tested passively to determine the relation between the degree of movement obtained in the various directions. This distinguishes a capsular pattern (due to arthritis) from a noncapsular pattern. The capsular pattern is quite specific for each joint but is the same irrespective of the type of arthritis (degenerative, rheumatoid, gouty, posttraumatic, etc.).

The patient tells the examiner when pain is provoked. It may take a substantial amount of persuasion to get beyond a painful arc. This means pain at the central part of a range of motion, disappearing as this point is passed in either direction. Pain may or may not reappear at the extreme of the range. A painful arc implies that a tender structure is being pinched between two bony surfaces.

A technique called, somewhat confusingly, "resisted movements" was developed by Cyriax to provide information concerning each muscle group surrounding a joint: its strength (*vide supra*) and whether it is painful. Properly performed so that no movement occurs at the joint, these maneuvers should be painless in arthritis (Cyriax, 1982).

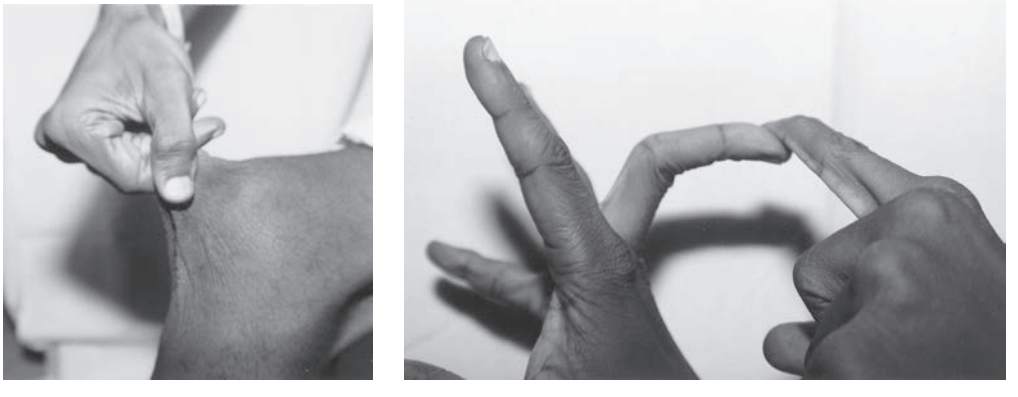
In patients with a previous history of direct injury or of surgical intervention, keep in mind the possibility of a neural origin for joint pain. Possibilities are a true neuroma, a stretch-traction injury, or entrapment of a nerve in the surgical scar. Local anesthetic blockade of the specific nerve that innervates that portion of the joint may be diagnostic (Horner and Dellon, 1994; Aszmann et al., 1996).

Increased Range of Motion

Ehlers–Danlos syndrome (cutis laxa) is the affliction of cutaneous hyperelasticity and joint hypermobility (Fig. 25-12), which are only the dramatic external heralds of important internal cardiovascular, mesenchymal, clotting, and gastrointestinal abnormalities. Child abuse has been erroneously diagnosed in children afflicted with this syndrome, in which capillary fragility can lead to purpura (Wardinsky et al., 1995).

The Shoulder

The shoulder contains the glenohumeral joint, the subdeltoid bursa, and the acromioclavicular joint, among other moving parts. It is frequently the site of ligamentous injury often called *rotator cuff* tears.



A B

Figure 25-12 Ehlers–Danlos syndrome. **A:** Hyperelasticity of skin. This is not seen in Marfan syndrome. **B:** A demonstration of increased joint mobility (which is not, in itself, diagnostic of the syndrome). (Courtesy of Dr Renee Ridzon, Massachusetts.)

Active Movements

Ask the patient to "elevate the arms" as far as possible. Some patients may do so in the coronal plane, bringing out a painful arc. Some may do so in flexion, perhaps to avoid anticipated pain; ask about it. Watch for asymmetry.

A painful arc at the shoulder suggests that something is being pinched between the head of the humerus and the acromion: the subacromial bursa or the tendon of the supraspinatus, infraspinatus, or subscapularis. Other causes are inflammation at the origin of the long head of the biceps or of the acromioclavicular joint.

Passive Movements

At the shoulder, there should be 90 degrees of abduction (before the scapula moves), 90 degrees of medial rotation, and 90 degrees of lateral rotation. A capsular pattern is present if, given *x* degrees limitation of abduction, there is more (say 2 to 3*x* degrees) limitation of external (lateral) rotation and less (say about 0.5*x* degrees) limitation of internal (medial) rotation (M. Ongley, *personal communication,* 1997). To check abduction, place your stabilizing hand over the scapula, using your thumb to attempt to keep the scapula from sliding sideways and forward. Use your other hand to elevate the patient's elbow in the coronal plane. The point at which the scapula slips from under your thumb is the point at which glenohumeral abduction has reached its full range (Fig. 25-13).

To check lateral rotation, the first movement to become limited as the capsule shrinks, flex the patient's forearm to 90 degrees, stabilizing it against the patient's trunk and usually your abdomen. Place one hand on the patient's other shoulder for stability and pull the supinated wrist of the tested arm backward, as shown in Fig. 25-14.

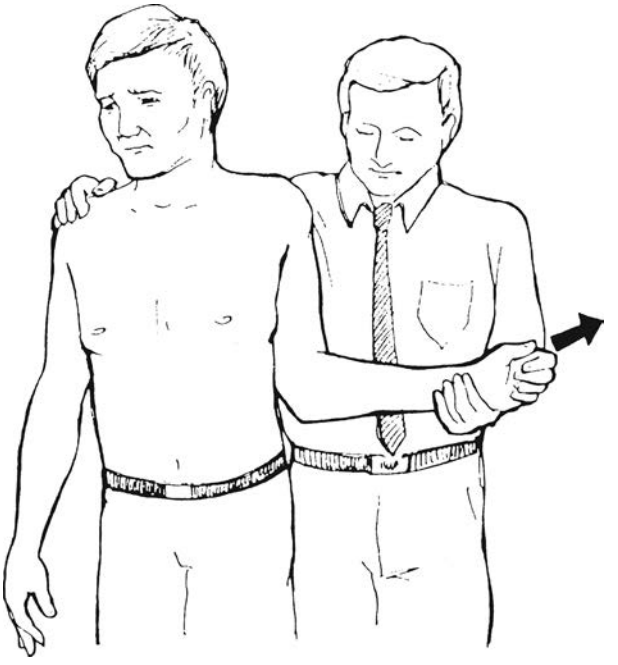


Figure 25-14 Passive assessment of lateral (external) rotation at the glenohumeral joint. (From Dorman TA, Ravin TH. *Diagnosis and Injection Techniques in Orthopedic Medicine.* Baltimore, MD: Williams & Wilkins; 1991, with permission.)

To assess internal rotation, as shown in Fig. 25-15, place the patient's forearm in the small of his back, raise the hand cephalad to its full range, and then draw the arm back as far as possible (gently, please!). Compare the distance with the other side.

A capsular pattern suggests a diagnosis of adhesive capsulitis, a surprisingly common condition, especially in women between

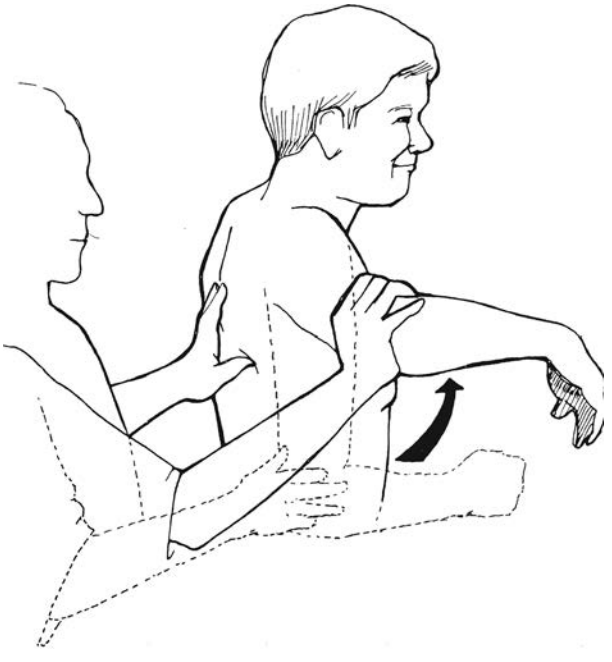


Figure 25-13 Testing abduction at the glenohumeral joint. The thumb pressed against the chest wall senses when the scapula escapes. (From Dorman TA, Ravin TH. *Diagnosis and Injection Techniques in Orthopedic Medicine.* Baltimore, MD: Williams & Wilkins; 1991, with permission.)

Figure 25-15 Testing medial (internal) rotation at the glenohumeral joint. This is also the position that places maximal stress on the infraspinatus tendon. (From Dorman TA, Ravin TH. *Diagnosis and Injection Techniques in Orthopedic Medicine.* Baltimore, MD: Williams & Wilkins; 1991, with permission.)

the ages of 40 and 60. The initial complaint may be pain when lying on the affected shoulder, which is usually the nondominant one. There may or may not be a history of trauma or overuse. Predisposing conditions include hypothyroidism or diabetes. The differential diagnosis includes a posterior dislocation and polymyalgia rheumatica (Johns and Counselman, 2001). Failure to treat early can result in a painful and disabling frozen shoulder; restoration of motion may require breakup of adhesions by manipulation under anesthesia (Dorman and Ravin, 1991). Some recommend a year of (painful) physical therapy. In this author's experience, a series of intra-articular triamcinolone injections is often curative.

Resisted Movements

In addition to checking for muscle strength (and hence nerve or central nervous system integrity), resisted movements (isometric contraction) can be used to help identify the precise source of pain in ligamentous injuries. Correctly diagnosed injuries may then be treated with precisely targeted injections, often with great success. Several maneuvers are illustrated in Figs. 25-16–25-18.

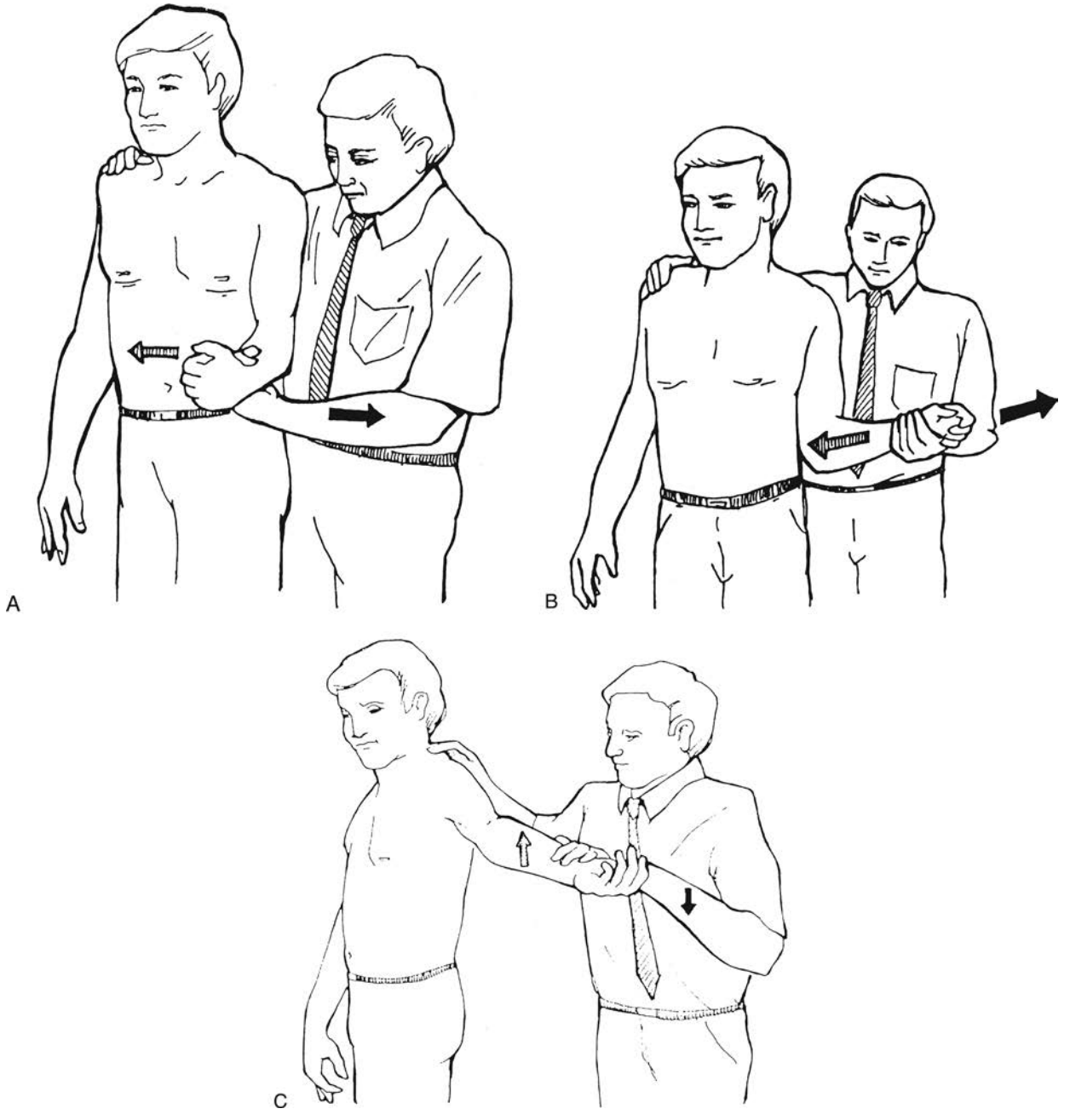


FIGURE 25-16 Testing the subscapularis by resisted movement. **A:** First check resisted internal rotation from the neutral position. **B:** The test is more sensitive from the position of maximal external rotation. **C:** An auxiliary test for the subscapularis. Place the arm horizontally, palm up in the coronal plane, and ask the patient to resist downward pressure. This motion squeezes the tendon under the acromion. (From Dorman TA, Ravin TH. *Diagnosis and Injection Techniques in Orthopedic Medicine*. Baltimore, MD: Williams & Wilkins; 1991, with permission.)

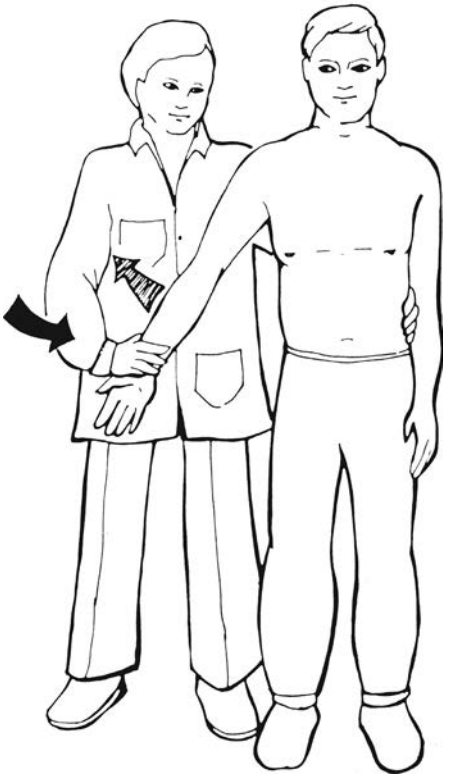


Figure 25-17 Resisted abduction tests the supraspinatus. Traditionally, the test was done with the arm at the side. This also tests the supraspinatus, although the movement of abduction from the side is initiated by the deltoid. (From Dorman TA, Ravin TH. *Diagnosis and Injection Techniques in Orthopedic Medicine.* Baltimore, MD: Williams & Wilkins; 1991, with permission.)

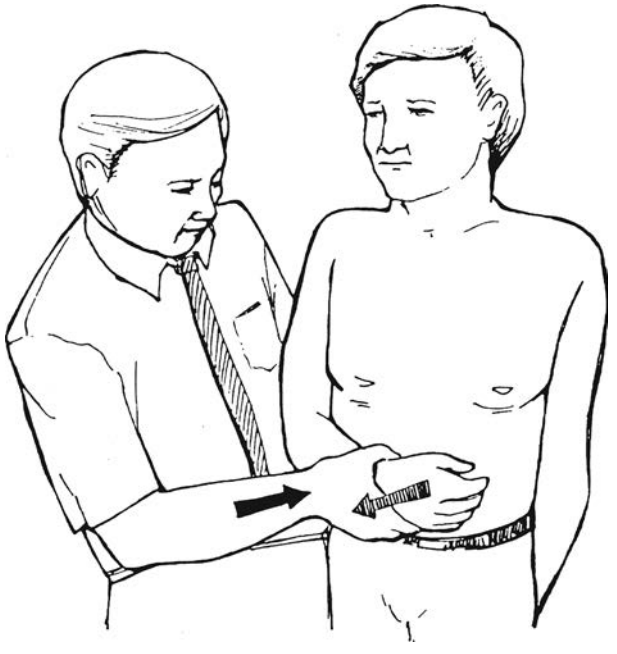


Figure 25-18 Resisted external rotation, starting with the hand on the upper abdomen, tests the infraspinatus. (From Dorman TA, Ravin TH. *Diagnosis and Injection Techniques in Orthopedic Medicine.* Baltimore, MD: Williams & Wilkins; 1991, with permission.)

Special Maneuvers for the Acromioclavicular Joint

Although the acromioclavicular joint is sometimes involved in spontaneous arthritis, usually problems arise from a fall on the shoulder or outstretched arm. Pain is referred to the tip of the shoulder. It is painful to lie on that shoulder. False signs of supraspinatus and infraspinatus tendinitis may be present because the tests (see Figs. 27-17 and 25-18) also stress this joint. Laxity in the joint may be demonstrated by grasping the distal end of the clavicle and the acromion in each hand, and wiggling it up and down when the patient is supine with arms relaxed and elbows flexed to 90 degrees. The joint is stressed by adducting the arm across the chest with a firm push, as shown in Fig. 25-19. (This maneuver also stresses the subscapularis tendon.) If the arm is held out horizontally in the coronal plane with the elbow flexed to 90 degrees, forceful internal rotation stresses the superior part of the joint and forceful external rotation stresses the inferior part (Dorman and Ravin, 1991).

Instability

The patient reports episodes of subluxation, dislocation, or fear that the shoulder is "going out." For the apprehension test, have the patient lie supine with the affected shoulder very close to the edge of the table. With the elbow bent at 90 degrees, abduct the arm to 90 degrees, and externally rotate the shoulder, so that the forearm is parallel to the table and the hand points cephalad. If the patient becomes apprehensive that the shoulder will dislocate, this sensation can be relieved with the Jobe relocation test: place your hand on the head of the humerus and gently push backward.

Differential Diagnosis of Shoulder Pain

The tip of the shoulder is a C4 structure and the outer aspect of the shoulder and arm are C5 structures. Visceral pain arising from these scleratomes is often referred to these areas. Possibilities include myocardial ischemia, pericarditis, subscapular splenic

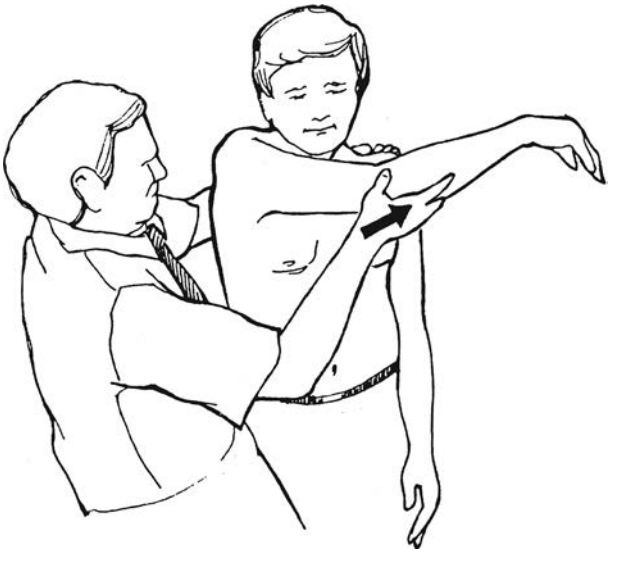


Figure 25-19 A test for the acromioclavicular joint. (From Dorman TA, Ravin TH. *Diagnosis and Injection Techniques in Orthopedic Medicine.* Baltimore, MD: Williams & Wilkins; 1991, with permission.)

hematoma, free blood under the diaphragm (as from an ectopic pregnancy), gallbladder disease, diaphragmatic pleurisy, and mediastinitis.

Pain arising in the neck (C6 and C7 scleratomes) is frequently referred to the shoulder (Fig. 25-9).

Shoulder–Hand Syndrome

This syndrome is the upper extremity manifestation of reflex sympathetic dystrophy syndrome, which begins with pain and tenderness in a distal extremity, accompanied by vasomotor instability, trophic skin changes, and rapid bony demineralization (Sudeck atrophy). Severe flexion contractures in the hand develop along with adhesive capsulitis of the shoulder. The mechanism is poorly understood. Precipitating events include trauma, myocardial infarction, stroke, and certain drugs.

The Elbow

Inspection and Palpation

The Pointing Test

The patient with tennis elbow generally points to the lateral epicondyle of the humerus as the site of his pain. With golfer's elbow, he generally points to the medial epicondyle.

Olecranon Bursa

Check for swelling, erythema, and warmth in the olecranon bursa. This is a frequent site for bursitis caused by repeated friction or trauma (as in "student's elbow").

Predisposing conditions include systemic lupus erythematosus, renal failure with dialysis, and diabetes. Infection is common and may require incision and drainage.

Passive Movements

The four passive movements to be tested at the elbow include flexion, extension, pronation, and supination. Check pronation and supination (rotation) with the arm at the side of the trunk and the elbow flexed to 90 degrees.

The capsular pattern is somewhat variable. Usually, flexion is two to three times more restricted than extension. In arthritis, rotation is usually full range and painless. Pain on rotation may mean that the head of the radius is cracked; radiography is indicated. Pronation and supination also check the wrist and the interosseus membrane of the forearm. A noncapsular pattern can be caused by a loose body.

Resisted Movements

Weak or painful resisted flexion at the elbow can result from a problem at the insertion of the biceps tendon into the bicipital tubercle of the radius. Painful resisted extension is rare and usually results from a shoulder problem such as subacromial bursitis.

In testing resisted flexion and extension of the elbow, remember that muscles originating on the humeral epicondyles and crossing the elbow have the action of flexing and extending the *wrist*.

To test the common extensor origin, have the patient straighten his elbow and extend his wrist. The patient holds this position firmly as the examiner attempts wrist flexion. Pain referred to the lateral epicondyle of the elbow is a sign of tennis elbow.

Resisted flexion of the wrist is tested with the wrist flexed, the elbow extended, and the forearm supinated. In golfer's elbow, pain is referred to the medial epicondyle of the humerus.

Examination of the elbow is not complete without checking the wrist and hand. A lesion near the elbow affecting the radial, median, or ulnar nerve may have distal signs only.

Referred Pain

The elbow may be the site of pain referred from the neck or the viscera, as in myocardial ischemia, esophageal disease, or, rarely, gallbladder disease.

The Wrist

Inspection and Palpation

Check for warmth, erythema, and synovial thickening, and observe the patient's use of his hands.

Range of Motion

The examiner takes the patient's hand as if to shake hands, controls the distal forearm with his free hand, and takes the wrist through a full range of flexion, extension, and radial and (last) ulnar deviation. Compare the two sides, and note the end-feel of movement and the joint play. When the joint is in a neutral position, the natural laxity of the capsule should allow some joint play, that is, motions such as gliding and angulation of the bones in directions different from the primary joint motions. A familiarity with normal joint play, acquired by experience, is especially important at the wrist or other joints in which the "spacers" are not attached to the "prime movers." Loss of joint play indicates displacement of one or more carpal bones or adhesions in one or more of the joint capsules or ligaments in the carpus (Dorman and Ravin, 1991).

Because the capsule of the wrist is tubular, arthritic shrinkage leads to proportional impairment of movement in all directions. A disproportionate (or noncapsular) pattern should signal an internal derangement of the carpal bones.

Resisted Movements

Remember that the wrist and the elbow function together. Test resisted movements at the wrist with the elbow straight to put the flexors and extensors of the two joints on the stretch.

Fractures and Dislocations

An extension injury (such as a fall on the outstretched hand) may result in a fracture at the waist of the navicular (also known as the scaphoid). Radiologic changes may be delayed. Proper treatment is immobilization in the "cock-up" position, with the thumb included in the splint. Findings include disproportionate limitation of motion and pain on extreme ulnar deviation, as well as marked tenderness to firm pressure in the anatomic snuff box. Squeeze the snuff box with your thumb while extending the patient's thumb. Also check for pain with axial compression of the thumb, or for pain in the snuffbox with resisted pronation at the wrist while holding the patient's hand as in a handshake. The scaphoid tuberosity may be checked by extending the patient's wrist with one hand while applying

pressure to the tuberosity in the proximal wrist crease with your other hand (Gutierrez, 1996). If this injury is suspected, immobilization is advised at least until radiographs can be repeated, with navicular views, in 10 to 14 days (Dorman and Ravin, 1991).

A ventral dislocation of the lunate (also called *the semilunar*), also an extension injury, is the most common dislocation at the wrist; close inspection reveals the contour of the wrist to be abnormal. On flexion, the capitate seems more prominent and a deficiency or dimple is seen dorsally just distal to the capitate. Flexion is likely to be slightly limited, with pain on the ventral side. This dislocation may be the cause of a carpal tunnel syndrome (*vide infra*). Radiographs are difficult to interpret because of the overlapping positions of the bones, but a lateral view should show the ventral displacement (Dorman and Ravin, 1991). Look for the three C signs on the lateral radiograph of the wrist: the curve of the distal radius, the curve of the carpal bones, and the base of the metacarpal. All three Cs are normally in line (J. Dwyer, *personal communication,* 1999).

de Quervain Tenosynovitis

Pain on the radial side of the wrist, worsened by grasping, making a fist, or twisting the wrist, may be caused by inflammation of the sheath of the tendons of the abductor pollicis longus or extensor pollicis brevis. The condition is generally attributed to overuse, or it may follow pregnancy. It must be distinguished from entrapment of the radial sensory nerve (see section on entrapment neuropathies and Table 25.4). In addition to a positive Finkelstein sign, patients with de Quervain tenosynovitis should have pain on resisted thumb extension or abduction and tenderness over the first extensor compartment on the radial side of the wrist.

The Finkelstein Sign

Have the patient make a fist with fingers over the thumb. Deviate the wrist to the ulnar side. Pain over the tendons on the radial side is a positive sign.

The Hand

Some deformities of the hand have been covered in Chapter 24. Entrapment neuropathies and peripheral nerve injuries affecting the hand are considered at the end of this chapter. The sensory and motor examination outlined in that section is an essential part of the evaluation of any patient with a hand injury.

Infection

In a patient who has experienced a penetrating hand injury, it is critical to be aware of the dangers of deep space infections, which can develop very rapidly with devastating consequences. Watch for swelling, redness (especially extending along tendon sheaths), and pain with finger motion.

The four Kanavel signs of tendon sheath infection, which requires urgent surgical decompression, are uniform digit swelling, finger held in flexion, tenderness along the entire finger, and exquisite pain on passive extension of the distal interphalangeal (DIP) joint (Cain, 1985).

Tendon Injuries

Tendon injuries, which require early, expert repair, are likely to be missed unless carefully sought. Check for range of motion and motion against resistance; compare with the uninjured hand (Cain, 1985).

Boutonnière (Buttonhole) Deformity

Rupture or laceration of the central extensor tendon slip at the proximal interphalangeal (PIP) joint with disruption of the extensor hood aponeurosis, as by a fall on the outstretched finger, results in a flexed position of the PIP and loss of extensor strength and range. The deformity worsens with time after the injury. To make an early diagnosis, check for a bruise and tenderness on the dorsal side of the PIP soon after the injury.

TABLE **25.4** *Comparison between de Quervain and Wartenberg syndrome*

Finding	de Quervain	Wartenberg
Pain dorsolateral wrist	+	+
Positive Finkelstein sign	+	+
Pain with resisted thumb extension or abduction	+	–
Tenderness over first extensor compartment	+	–
Tinel sign present over junction of BR and ECRL tendons	–	+
Symptoms worse with forearm pronation or pressure over BR/ECRL junction	–	+
Abnormal sensory findings, radial distribution	–	+

BR, brachioradialis; ECRL, extensor carpi radialis longus.
From Mackinnon SE, Dellon AL. *Surgery of the Peripheral Nerve.* New York: Thieme Medical Publishers; 1988, with permission.

Extensor Pollicis Longus

This muscle inserts on the distal phalanx and extends all the joints of the thumb. Because the thumb can be extended to 0 degrees at the interphalangeal (IP) joint with the intrinsic muscles alone, rupture of the tendon of the extensor pollicis longus will be missed if only the IP joint is checked. The best test is to place the hand flat on the table and have the patient lift only the thumb.

Mallet Finger

The extensor tendon is detached from its insertion on the distal phalanx by an axial force on the outstretched finger, resulting in inability to extend the joint actively. A ventral subluxation of the joint may be associated.

Flexor Digitorum Profundus

Stabilize the PIP in extension and ask the patient to flex the distal joint of each finger. Also check distal flexion against resistance (Figs. 25-28 and 25-32). The same procedure is used for the thumb, stabilizing the metacarpophalangeal (MCP) joint.

Flexor Digitorum Superficialis

While holding the other fingers and the MCP joint in extension, ask the patient to flex the middle digit (PIP); recheck against resistance.

The Hip

History

With arthritis, pain is aggravated by walking or sometimes with maintaining one position for a long time. Diminution of pain after warming up and recurrence with prolonged exercise is typical of osteoarthritis.

Twinges of pain with sudden, unpredictable giving way suggests the presence of a loose body in the joint.

Inspection

The Pointing Test

When asked to point to the site of pain, the patient with hip joint disease will usually point to the groin. Less frequently, pain is felt deep in the buttock or posterior to the greater trochanter or, occasionally, anteriorly and medially down the shin as far as the ankle. In children, a hip lesion might present with pain at the knee and vice versa. This false localization may persist into adulthood (Dorman and Ravin, 1991). (In male patients with groin pain, do not forget to check for a hernia, Chapter 21).

A Caveat. Greater trochanteric bursitis has been termed *the great pretender* in orthopedics and general practice. Patients with pain in the greater trochanter have bursitis but this is seldom primary. Although treating the greater trochanteric bursitis may be effective, the ultimate diagnosis (hip or lumbosacral spine pathology) remains to be determined (J. Dwyer, *personal communication,* 1999).

Posture

Look for slight flexion and medial (internal) rotation while the patient is standing. Sometimes the foot on the affected side is placed slightly ahead of the other. When lying down, the patient may tend to roll toward the good side and flex the bad side.

A hip fracture might be diagnosed by inspection from the end of the stretcher by observing the external rotation of the foot.

The Trendelenburg Sign

Have the patient stand, unassisted, on each leg in turn. Normally, the buttock on the weight-bearing leg is lower because the contralateral hip is lifted up so as to move inward toward the center of gravity. The patient with hip dislocation, or paralysis of the gluteus medius, is unable to lift the abnormal buttock into this elevated position. Thus, a positive Trendelenburg sign is a lower buttock on the non–weight-bearing side. False positives occur if the patient is allowed to lean on something, or if the hip adductors are weak. A better way to diagnose a dislocated hip is to check the range of motion or obtain an X-ray.

A one-legged squat may bring out core weakness not detected by the Trendelenburg test. Asked to stand on one leg and perform repetitive quarter or half squats, the patient may use his arms for balance or go into an exaggerated flexed or rotated posture called "corkscrewing" to help gluteal or short rotator muscles compensate for other muscular weakness (Sciascia and Kibler, 2006).

Passive Movements

Congenital Subluxation

An important part of the screening examination in infants is to detect this condition before it progresses to complete dislocation. One method is to check for limitation of external rotation: With the infant supine, flex the knees and the hips to right angles. Then externally rotate the hips by attempting to push the knees laterally to the examining table. Normally, both knees will go to the table, or almost to the table, and the angles formed with the table will be symmetric; in congenital subluxation, however, the knee on the affected side will either not reach the table or not come as close to the table as the other side.

A Note of Caution. Routine testing for congenital dislocation has caused fractures of the femur in infants with osteogenesis imperfecta or brittle bones secondary to copper deficiency. All but about 10% of the infants at risk may be identifiable by family history or blue sclerae. Distress after the examination is an indication for radiography. Ultrasound screening may be preferable to this portion of the physical examination (Paterson et al., 1992).

Range of Motion

Check flexion with the patient supine and the knee flexed to 90 degrees by attempting to place the knee on the chest. Stabilize the pelvis by placing your hand on the contralateral knee. The point at which the contralateral knee begins to rise from the table indicates the limit of flexion on the side being tested. The normal individual can place the thigh on the trunk, but the last 45 degrees of this apparent hip movement actually constitute flexion of the pelvis at the lumbar joints.

Check lateral (and medial) rotation by flexing the knee and hip to 90 degrees, moving the foot toward (and away from) the midline (Fig. 25-20). Normal range is 60 degrees of lateral and 45 degrees of medial rotation. This is a convenient time to test resisted movements of the hip rotators (*vide infra*). For completeness, check abduction and adduction, also with the hip and knee flexed to 90 degrees by moving the knee toward and away from the midline. This maneuver generally is only confirmatory.

Complete the supine examination, including the straight-leg raising test and strength testing before having the patient turn into the prone position.

Normal extension, tested with the patient prone, is about 30 degrees. This is the first movement to be curtailed in arthritis, although medial rotation is the one limited most in magnitude. Subtle limitations in medial rotation, and asymmetry between the two sides, can best be appreciated by flexing the knees to 90 degrees and pressing the feet apart, with the patient still prone.

The end-feel at the limits of passive motion is especially helpful at the hip. In arthrosis, the extreme of passive flexion or rotation is very hard. In bursitis or with an impacted loose body, the end-feel is soft (Cyriax, 1982).

Capsular Pattern

The pattern of capsular limitation of motion in gross arthritis is as follows: (a) fixed in slight adduction; (b) severely limited medial rotation (which is the most painful passive movement); (c) 90 degrees limitation of flexion; (d) 10 to 30 degrees limitation of extension; and (e) full lateral rotation.

Resisted Movements

Resisted flexion with the straight leg just a little above the examining table tests the rectus femoris and sartorius.

Testing resisted flexion with the hip and knee flexed to 90 degrees primarily examines the iliopsoas. An obturator hernia interferes with the pelvic course of the iliopsoas. Pain in the iliac fossa on resisted flexion, relieved after lying in the Trendelenburg (head-down) position for 10 minutes, appears to be pathognomonic (Cyriax, 1982).

FIGURE 25-20 Testing medial (internal) rotation of the hip. Push on the knee while pulling the foot toward you. The examiner's fingertips are just seen on the patient's instep. To test resisted movement, exert more pressure and ask the patient to "keep it there." This tests the medial rotators of the flexed leg.

Pain on resisted lateral rotation may be a sign of the piriformis syndrome.

Pain on resisted adduction may be caused by rider's strain in the athlete. It is also elicited in fracture or neoplastic invasion of the pubic bone.

Checking resisted extension and flexion at the knee (*vide infra*) is part of the examination of the hip muscles.

The Knee

History

With the exception that hip problems are sometimes falsely felt in the knee, and vice versa, patients usually identify the knee correctly as the site of a problem. Pain from the coronary ligament is generally felt at the site, whereas most other problems are felt in the knee as a whole. A history of transient locking in extension indicates a loose body. Locking in flexion signifies a torn meniscus; the patient may hop into the room with the affected knee held in flexion, the limb medially rotated, and the foot in plantar flexion. Sudden, recurrent pain and the sense of something "going out," perhaps coming on after squatting, is characteristic for lateral dislocation of the patella, especially common in young women with valgus deformities (*vide infra*).

In a patient with an acute injury, have the patient describe the position of the knee and the foot, and the direction of forces at the time of the injury.

Inspection

With the patient seated, inspect the knees for symmetry and for general joint configuration and muscle development. A somewhat posteriorly placed tibial tubercle may be the first visual clue to laxity of the posterior cruciate ligament. Atrophy of the medial head of the gastrocnemius or asymmetric deficiency of the vastus lateralis and the adductors suggests knee dysfunction. Check whether one patella is higher than the other, a sign of asymmetric muscle action. If the outline of the infrapatellar tendon is obscured, it suggests a weak posterior cruciate ligament.

Look for swellings with the knee in both flexion and extension. An effusion within the knee joint itself may obliterate the hollows lateral to the patella.

With the patient standing and the knee fully extended, check for a swelling distal to the transverse popliteal crease. This may be a Baker cyst, which is an abnormal communication between the knee joint space and one of the bursa, usually the gastrocnemius-semimembranosus bursa (Schmidt et al., 1974). Such potential communications are found in more than half the population (Good, 1964) but do not usually attract attention until and unless there is an intra-articular chronic effusion that expands the Baker cyst (producing "dissection"). Prominent popliteal fat pads may obscure, or be mistaken for a Baker cyst. The location may be misleading, as some Baker cysts present at the midcalf, midmedial calf, or lower portion of the leg if they have silently dissected downward since their inception (Schneiderman, 1990).

The crescent sign of a ruptured Baker cyst is shown in Fig. 24-11.

Varus and Valgus

Varus was a Roman general, famous for being knock-kneed. In fact, he became eponymic in the Latin language for his affliction. Valgus, on the other hand, is the Latin word for bowlegged. The ignorant have perverted these words by exporting them in adjectival form to other portions of the body. The confusion may have started from the fact that when the varus knees point in, the valgus hips point out, compensatorily. In distant climes, the words were so abused and tortured that when they were finally returned to the knees, they were assigned a meaning exactly opposite to that which they possessed prior to their diaspora. Currently, the English medical dictionaries and Latin–English dictionaries define these words oppositely. Thus, it is now impossible to use either of them in an intelligent manner. I suggest a moratorium on the use of words by persons who know not the language. Knock-kneed and bowlegged have the inestimable advantages of being precise and unambiguous. Those wishing to retain the Latin so as to sound impressive should remember, *"Qui stultis videri eruditi volunt stulti eruditis videntur"* (Quintilian, IX, 7,22).[3] The English-speaking orthopedist's mnemonic is as follows: valgus with a "g" as in "gum" means knees that stick together, and varus means a variance or divergence (J. Dwyer, *personal communication,* 1999).

Palpation

Warmth

Palpate for warmth with the back of the hand.

Tenderness

In youngsters, bilateral tenderness of the tibial tuberosities is said to be probably pathognomonic of Osgood–Schlatter disease, which is osteochondrosis of the tibial tuberosity (Fairbank, 1937). In this condition, there is partial separation of the epiphysis of the tibial tuberosity, usually resulting from a sudden pull by the ligament of the patella during exercise.

Chondromalacia

Chondromalacia causes anterior knee pain, generally in sedentary young women, provoked by unaccustomed exercise. To test for this condition, extend the patient's leg, stabilize the patella with one hand, press down, and rub the patella back and forth. With chondromalacia this maneuver causes acute pain and may also cause creaking.

Bursitis

Fluid may accumulate in any of the bursae around the patella. There is pain, inflammation, and a boggy sensation, with or without frank fluid. Inflammation in the subcutaneous prepatellar bursa over the lower part of the patella is called *housemaid's knee*. Involvement of the subfascial prepatellar bursa between the fascia and the tendinous expansion in front of the patella is called *priest's* or *surf-boarder's infrapatellar bursitis*. A posteromedial bursitis may not be possibly differentiated from a Baker cyst (*vide supra*).

Effusion in the Knee Joint

Relatively large amounts of fluid in the joint may be detected by ballottement:

1. Have the patient pine with knees extended.
2. Encircle the suprapatellar region with one hand, compressing the suprapatellar pouch.
3. Tap on the patella sharply with the other hand. If there is a sufficient quantity of fluid, you will feel the patella click against the femur.

Relatively small amounts of fluid may be demonstrated by the bulge sign:

1. Have the patient lie supine with the knee fully extended and the muscles relaxed.
2. Stroke the medial aspect of the knee to express the synovial fluid from this area.
3. Tap the lateral aspect of the knee and watch for the appearance of a bulge on the medial side. It may be necessary to tap several times to find the optimal percussion area, usually the area just above the midportion of the patella.

Passive Movements

Range of Primary Motions

With the patient supine, test extension by placing one hand on the thigh to stabilize it firmly on the examining table and lifting the ankle with a jerking movement. Normally, 10 to 15 degrees of hyperextension is possible. Test flexion by placing the heel against the buttock, first medially and then laterally, using one hand to sense any laxity in the capsule. Test for hyperflexion by placing your forearm in the crook of the knee while flexing the knee forcibly.

A capsular pattern is a slight limitation of extension and a much greater limitation of flexion.

If one knee has limited extension compared with the other, the heel on that side will be higher when the patient lies prone.

Testing the Ligaments

To examine the *medial collateral ligament* place one hand on the lateral aspect of the knee and the other hand on the foot; then place a strain on the ligament with an abduction maneuver, first with the knee straight and then with the knee flexed to 30 degrees. To examine the lateral collateral ligament, shift your hand to the medial aspect of the knee and apply an adduction stress (Fig. 25-21).

The *coronary ligaments,* which attach the menisci to the tibia, are stressed by rotation of the foot with the knee flexed. Figure 25-22 shows the examiner placing a stress on the lateral coronary ligament by internal rotation of the foot. This is painful if the ligament is sprained.

The *cruciate ligaments* are tested with the drawer sign. The knee is flexed to 90 degrees, and the foot is stabilized by the examiner, as if by sitting on it (Fig. 25-23). The examiner pulls the tibia forward with a strong jerk. Wiggle the knee forward and backward; only very slight movement is normally possible.

Contrary to expectations, it has been shown in cadavers that after the anterior cruciate ligament has been cut, the range of motion in the anterior drawer test remains normal, stability presumably being conferred by the posterior cruciate and the joint capsule. Performing the test with the foot internally rotated is a better test for the anterior cruciate, whereas rotating the foot externally helps isolate the posterior cruciate (Dorman and Ravin, 1991).

[3] Whosoever wishes to appear learned among the stupid will appear stupid among the learned.

Figure 25-21 Testing the lateral collateral ligament.

In various studies, some very small, the sensitivity of the anterior drawer sign ranged from 9% to 93% and the specificity from 23% to 100%. The likelihood ratio (LR) of a positive test was 3.8 (95% CI, 0.7–22.0), and that of a negative test, 0.3 (95% CI, 0.05–1.50). (Solomon et al., 2001).

Resisted Movements

Resisted flexion and extension are best examined with the patient lying prone so as to maintain extension at the hip, although for convenience they are sometimes tested with the patient supine. With the knee flexed to 90 degrees, push on the heel and ask the patient to resist. To check resisted extension with the patient prone, push down on the extended knee, pull up on the ankle, and ask the patient to push the foot down.

Painful extension points to a lesion in the quadriceps. Painful and weak extension suggests a fracture of the patella or a rupture in the muscle belly. Painless weakness of extension suggests an L3 palsy.

If flexion of the knee is painful, test medial and lateral rotation of the flexed leg with the hip and knee passively flexed to 90 degrees. This test distinguishes between a problem with the upper tibiofibular joint or the biceps (a lateral rotator) and with the semimembranosus, semitendinosus, and popliteus muscles (medial rotators) (Cyriax, 1982).

Figure 25-22 Testing the lateral coronary ligament by internally rotating the foot.

Figure 25-23 Testing the cruciate ligaments.

More Special Maneuvers

There are numerous special maneuvers designed to diagnose what have been called "internal derangements of the knee (IDK)," only a few of which can be described here. It has been noted by Smillie (Bailey) that the abbreviation "IDK" also stands for "I don't know."

The Lachman Test

This is another test for the integrity of the anterior cruciate ligament.

A Method:

1. Have the patient lie supine with the heel on the examining table and the knee flexed 20 or 30 degrees.
2. Standing to the side of the examining table, grasp the femur firmly with one hand to prevent motion of the upper leg and to relax the hamstrings.
3. Grasping the proximal tibia with your other hand, give the lower leg a brisk forward tug. A discrete endpoint should be felt.

Interpretation. In a positive test, the endpoint is not discrete or there is increased anterior translation of the tibia.

The sensitivity of the Lachman test has ranged from 60% to 100%. The specificity was reported to be 100% in a single study of limited generalizability. The LR for a positive test was 42.0 (95% CI, 2.7–651) and for a negative test, 0.1 (95% CI, < 0.0–0.4) (Solomon et al., 2001).

A Variation. If the examiner's hands are small and the patient's legs are large, the patient may be placed prone.

The McMurray Test

The McMurray test provides information on the posterior horns of both the lateral and medial menisci.

A Method:

1. Have the patient lie supine, and flex the hip and knee until the heel touches the buttock.
2. Steady the knee with one hand, and grasp the patient's heel with the other. Rotate the patient's foot laterally as far as possible, and then bring the knee back to a 90-degree angle.
3. Now relax the rotation and return the heel back toward the buttock. Rotate the foot medially, thus placing the knee in internal rotation, and slowly extend the knee.

Interpretation. The test is positive for a torn medial meniscus if, during the extension of the leg thus held in external rotation, the patient's symptoms are reproduced, especially if you hear or feel a click. The patient should be able to state that the sensation is the same as that experienced when his knee previously gave way (McMurray, 1942). Results analogous to those in step 2 are a positive test for disease of the lateral meniscus. A positive sign may be accompanied by an inability to fully extend the knee.

Using arthroscopy as the standard, the mean sensitivity of the McMurray test was 53% and the specificity was 59%. The LR for a positive test was 1.3 (95% CI, 0.9–1.7) and for a negative test, 0.8 (95% CI, 0.6–1.1) (Solomon et al., 2001).

The Medial–Lateral Grind Test

The medial–lateral grind test also checks the integrity of the menisci.

A Method:

1. With the patient supine, cradle the calf in one hand and place the index finger and thumb of the opposite hand over the joint line.
2. Apply varus and valgus stresses to the tibia during flexion and extension.

Interpretation. Detection of a grinding sensation over the joint line is deemed a positive test. The sensitivity is reportedly 69% and the specificity, 86% (Solomon et al., 2001).

The Fairbank Apprehension Test

Recurrent subluxation of the patella in young women may masquerade as meniscus injury. The Fairbank apprehension test (Fairbank, 1937) is positive in recurrent subluxation but not in meniscus injury. With the patient sitting so that the knee is flexed, grab the patella and slowly begin to push it laterally. The patient with patellar subluxation will immediately become apprehensive. She may even grab your wrists because she "knows" that "it" is going to happen again if you keep pushing in that direction.

The Ankle

History

In case of trauma, the patient with a fracture is usually unable to walk immediately after the accident. With sprains, as in ligamentous injuries elsewhere, the patient may be able to bear weight at first, but symptoms worsen several hours after the injury. The distinction is not reliable enough to preclude the need for radiography.

Inspection

An effusion into the ankle joint produces bulging beneath the extensor tendons and a fullness just anterior to the lateral and medial collateral ligaments. The foot tends to be held in slight dorsiflexion and inversion. The best way to detect an early effusion is to view the joint from behind and to look for fullness in the fossae behind the malleoli, comparing them with the normal side (Clain, 1973).

Palpation

In a rupture ("sprain") of the calcaneofibular (lateral malleolar) ligament caused by a forced inversion of the foot, the tenderness is located anterior and possibly inferior to the lateral malleolus rather than over the malleolus itself. This finding helps to differentiate a sprain from a fracture. In ankle injury, be sure to check the superior tibiofibular joint. As the patient sits on a high table, stabilize the leg with one hand, grasp the fibular head between your finger and thumb, and apply firm forward-and-backward pressure, checking for pain and the range of glide.

Passive Movements

The ankle is a hinge joint normally capable of 20 to 30 degrees of dorsiflexion and 30 to 50 degrees of plantar flexion. It forms a functional unit with the subtalar and midtarsal joints. The former permits inversion and eversion of the foot. The latter consists of the talonavicular and calcaneocuboid joints, which permit dorsiflexion, plantar flexion, adduction, abduction, and lateral and medial rotation. To check these motions, the heel must be pulled down and held still to prevent motion at the other joints.

Resisted Movements

Resistance testing for strength (*vide supra*) is very important in diagnosing nerve root lesions and other neurologic problems.

Pain on resisted eversion of the foot is a sign of peroneal tendinitis.

The Foot

The examination of the skin, nails, pulses, and joints, as described in Chapters 7, 18, and 24, may be done for convenience in the course of the musculoskeletal examination. (Many of the arthritic conditions described in detail for the hands have comparable manifestations in the feet.) The sensory examination—which is of special importance in diabetic patients—and other aspects of the neurologic examination are described in Chapter 26. Any examination of the foot will include all of the above.

In this section, only a few orthopedic conditions will be mentioned.

Pes Cavus

Pes cavus means "arched (or cavernous) foot." In fact, it appears as if the foot has been prepared by nature for the wearing of high heels, as the plane surface of the heel is several inches above the plane surface of the metatarsal heads and the toes. It may be unilateral or bilateral, depending on the etiology, and is often accompanied by "hammer" toes (so called because they are "cocked back" like a gun hammer). Pes cavus can be seen only with the shoes and socks removed.

Pes cavus is sometimes called "horse foot" (pes equinus) because the toes and the metatarsal heads resemble the hoof and the heel resembles the higher portion of the horse's foot. However, this is a misnomer because patients with pes cavus do bear weight on their heels, albeit the more posterior portions.

The etiology is usually neurologic (e.g., Friedrich ataxia, Charcot–Marie–Tooth peroneal atrophy, old poliomyelitis, spastic hemiplegia, or diplegia) or muscular (e.g., muscular dystrophy). I have also seen it in Sipple syndrome and neurofibromatosis.

Pes Planus

The longitudinal arch is flattened, predisposing to pain in the forefoot due to ligamentous strain. Pes planus is one of the criteria for Marfan syndrome and is also seen in Ehlers–Danlos syndrome but is not specific for such conditions.

Plantar Fasciitis

Plantar fasciitis is a common condition that presents with pain on walking. The pain may be reproduced by extending the big toe passively with one hand while palpating the medial side of the fascia in the sole of the foot. The condition is often associated with the radiographic finding of a heel spur, which is secondary and not the cause of the problem. Plantar fasciitis is especially common in patients with Reiter syndrome. Recurrent symptoms, especially if unrelieved by proper footwear with a heel elevation, suggest the need to evaluate for an underlying foot or gait abnormality. Such patients may have pain of neural origin, as from tarsal tunnel syndrome (*vide infra*) that was misdiagnosed (Dellon, 2001). A careful sensory evaluation, as with the pressure-specified sensory device or PSSD (Fig. 25-24), could help prevent inappropriate surgery. Techniques for sensory testing will be explained more fully in Chapter 26.

Peripheral Nerve Injuries and Entrapment Neuropathies

Thoracic Outlet Syndrome

As the thoracic outlet is actually the diaphragm, the term is a misnomer that gained common acceptance after a 1956 article entitled "thoracic outlet syndrome," which described specific physical therapeutic maneuvers for treating symptoms of brachial plexus compression in the thoracic *inlet*. The condition was previously called the "scalenus anticus syndrome." This is an "anatomically goal-directed" terminology, as was the "costoclavicular syndrome," as surgeons determined which structures ought to be resected. A number of patients had an anterior scalenectomy or scalenectomies, with or without a cervical rib resection (if one was present), often without improvement. There were also advocates for resecting a normal first rib or even the clavicle (Mackinnon and Dellon, 1988).

The classic history is that the patient awakens with tingling in the hands 2 to 4 hours after falling asleep, thereby relieving pressure on the brachial plexus. This is the model for the release phenomenon (Dorman and Ravin, 1991).

Provocative tests (also see Chapter 18) include raising the arms above the head, applying pressure to the brachial plexus just posterior to the anterior scalenus muscle for 10 to 60 seconds, or holding the forearm and arm at a 90-degree angle to the body (the "stick 'em up" or surrender posture). If the last maneuver reproduces the symptoms in less than 1 minute, the patient is said to have a positive Roos sign (Mackinnon and Dellon, 1988).

There may be a positive Tinel sign, with tingling in the ulnar side of the hand and fingers evoked by tapping in the supraclavicular fossa with the head turned to the contralateral side (Campbell et al., 1991).

As electrodiagnostic testing cannot identify compression of the brachial plexus in the thoracic inlet, noninvasive and nonpainful sensory testing as with the PSSD (Figs. 25-24 and 25-36) can document clinically significant problems. With the hands at rest after the provocative maneuvers described above, the index finger is tested to check the upper part of the plexus (C6), and the little finger is tested to check the lower part (C8) (Howard et al., 2003).

Diligent nonoperative management is advised before resorting to surgery.

Sometimes abnormal mobility of the first rib can be demonstrated. The examiner stands behind the patient, placing his index fingers in the space between the first rib and clavicle, comparing the respiratory motion of the rib on the two sides (Dorman and Ravin, 1991).

The differential diagnosis includes intramedullary or extramedullary spinal cord processes, such as a glioma or central cervical disc protrusion, a pulmonary sulcus (Pancoast) tumor, compression neuropathy of the median or ulnar nerve, and traction lesions of the brachial plexus as from carrying a heavy knapsack or from positioning during surgery.

Quick Tests of the Nerves to the Hand

Horenstein's "Handy Guide" to the Hand Nerves

The entire hand innervation (motor) can be tested by examining the forefinger, which is chosen because the innervation is most constant. The radial nerve is tested by finger extension at the MCP joint. The median nerve is tested by extension at the DIP joint. Brace the finger straight with the DIP flexed, and then ask for the DIP to be extended so that "the whole finger is straight." (This is the action of the lumbricales.) The ulnar nerve is tested by having the extended forefinger perform abduction or adduction, the former being easier for the patient. (This is the action of the interossei.)

Flint's Quick Tests for the Injured Hand

Be sure to test both motor and sensory functions before administering local anesthesia.

FIGURE 25-24 Testing the sensibility of the calcaneal nerve with the pressure-specified sensory device (PSSD), manufactured by NK Biotechnical Corporation. The patient presses a button when she detects pressure at two points. The computerized device records the pressure exerted and the distance between the two points. Several different measurements can be made and averaged.

Sensory

The "autonomous" sensory nerve zones on the hand are as follows: tip of the little finger (ulnar); tip of the index finger (median); and dorsal web space between the thumb and index finger (radial). See Chapter 26 for techniques of sensory testing.

The "Wrinkle" Test

The wrinkle test can be especially helpful for children who are too frightened to give reliable responses. A normal finger will wrinkle after 5 minutes of soaking in sterile water; a denervated finger will not.

Motor

The simple test of holding a pencil by the eraser between the thumb and, successively, each other digit is an excellent indicator of nerve or tendon injury (Cain, 1985).

Radial Nerve

One test for acute radial nerve damage is a motor test. See whether the patient can extend his hand at the wrist against the resistance of gravity or of your own hand (Fig. 25-25).

In chronic disease of the radial nerve, look for a spontaneous wrist drop.

There are two branches of the radial nerve. If the deep branch is the only one involved, the patient can have the finger drop but not the wrist drop. This is important because one cannot refute the hypothesis of radial nerve damage on the basis of the absence of the wrist drop (hence the reason for using the forefinger in the Handy Guide). Physicians involved in worker's compensation should be especially chary about diagnosing such patients as conversion reactions.

FIGURE 25-25 Testing radial nerve extrinsic motor function. Ask the patient to keep his wrist extended as you press on the dorsum of the hand. (Photograph by Patti Wylie.)

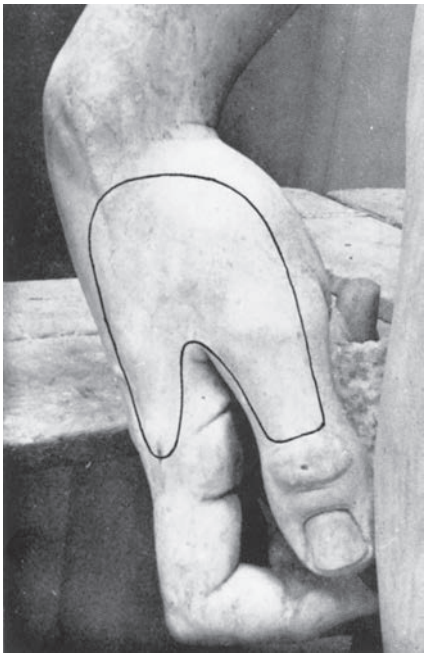


Figure 25-26 Although anatomic variability makes most universal statements suspect, sensation within the marked area is carried by the radial nerve in almost everyone. (Detail from *David,* by Michelangelo.)

If motor evidence of a radial nerve injury is found, clinch the diagnosis by demonstrating the specific sensory involvement. The best place to test the sensory branches of the radial nerve is on the dorsum of the thumb and adjoining dorsum of the hand proper (see area indicated in Fig. 25-26).

Wartenberg Syndrome

Compression of the sensory branch of the radial nerve in the forearm was first described in 1932 by Robert Wartenberg. Several cases have been described as secondary to wristwatches and recent descriptions have been case reports of "handcuff neuropathy." Patients may have a history of trauma or an occupation involving repetitive pronation/supination or ulnar/radial deviation. Predisposing conditions include diabetes and rheumatoid arthritis. The patient generally presents with pain, numbness, or abnormal sensations over the dorsoradial aspect of the hand.

A careful sensory examination should reveal differences between the two hands, and the Tinel sign is often positive along the course of the radial nerve in the forearm. The differential diagnosis includes de Quervain tenosynovitis (*vide supra*). Findings are compared in Table 25.4.

A Provocative Test

Have the patient place his extended arm in front of him, with the forearm hyperpronated and the wrist in ulnar deviation. The test is positive if numbness and tingling occurs in the dorsoradial aspect of the hand within 1 minute. One can also provoke symptoms with the hand in this position by pressing on the musculotendinous junction of the brachioradialis muscle.

Ulnar Nerve

Tests of Motor Function

The Froment Newspaper Sign

The Froment newspaper sign is a good test for acute ulnar nerve damage.

Have the patient grasp a piece of newspaper (or writing paper) with each hand between the tips of the thumb and index finger. Then instruct him to pull laterally with each hand to tauten the test object. In cases of acute ulnar neuropathy, the paper will slip from the thumb on the affected side.

A Caveat. Please note that this test requires that the median nerve be intact so that the index finger can flex.

Unambiguous Motor Tests for Ulnar Nerve Damage

An intrinsic muscle that is innervated solely by the ulnar nerve is the first dorsal interosseus (Fig. 25-27) and an extrinsic muscle is the flexor digitorum profundus of the little finger (Fig. 25-28).

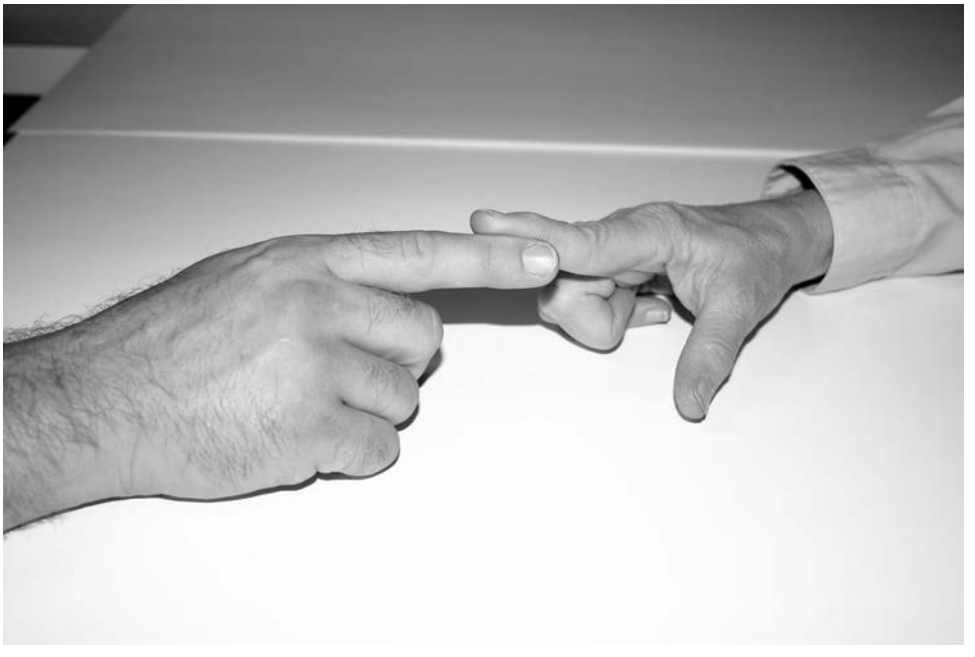


Figure 25-27 Ulnar intrinsic muscle function may be tested by having the patient abduct the index finger against resistance and observing the contraction of the first dorsal interosseus muscle. (Photograph by Patti Wylie.)

FIGURE 25-28 Ulnar extrinsic muscle function may be tested by having the patient hold the distal phalanx of the fifth digit in flexion against resistance as the PIP and MCP joints are extended. (Photograph by Patti Wylie.)

Claw Hand Deformity

Patients with a chronic ulnar palsy will be unable to extend the little finger at its IP joints. Sometimes the ring finger shares this posture. The fingers are hyperextended at the MCP joints, the hypothenar eminence is flattened, and the palm is hollowed. Together these produce the characteristic *main en griffe,* which has been translated as "claw" hand but could also be translated as "talon" hand.

Sensory Abnormalities

Once you have detected motor evidence of ulnar nerve disease, clinch the diagnosis by checking sensation on the little finger.

Palpation

The ulnar nerve is probably the only nerve in the body that is readily palpable *in vivo*. It lies in the groove between the olecranon process and the medial epicondyle of the humerus. This groove is posterior and distal to the place where you palpate for epitrochlear nodes.

Try finding your own ulnar nerve. When it is pressed lightly, you may experience a noxious sensation. If the nerve is touched too vigorously, the result is paresthesias or the sensation known as "hitting the funny bone"—probably thus named because it lies near the humorous humerus. If an ulnar nerve feels enlarged and stiffened, you can diagnose interstitial hypertrophic neuritis.

There are many causes for ulnar nerve compression at the elbow, including fractures, arthritis, external compression as in postanesthetic or in bedridden patients, occupational postures or movements, congenital anomalies, and alcoholism. Symptoms can be provoked as shown in Fig. 25-29.

FIGURE 25-29 Symptoms of ulnar nerve compression can be provoked by flexing the elbow and exerting pressure over the ulnar nerve just proximal to the cubital tunnel, which lies between the two heads of the flexor carpi ulnaris. Some prefer just to tap this area looking for the Tinel sign as evidence for a cubital tunnel entrapment neuropathy. (Photograph by Patti Wylie.)

FIGURE 25-30 Patient with a median nerve injury is unable to form a circle with the thumb and forefinger. (Photograph by Patti Wylie.)

Median Nerve

Motor Signs

A good motor test for acute median nerve disease is the Ochsner clasp sign. Have the patient clasp his hands together as if in prayer, but more tightly. If the motor branch of the median nerve is diseased, it will not be possible for the patient to flex the index finger on that side, and it will stick up from the clasped hands.

The best chronic motor sign is also based on the inability to flex the index finger, and sometimes the middle finger. When the other two fingers are flexed, the result is the benediction sign or the papal hand. This has also been compared with the position of the gynecologist's hand at the introitus.

Because the patient with an injury to the median nerve or the anterior interosseus nerve in the forearm is unable to flex either the IP joint of the thumb or the DIP joint of the index finger, attempts to form a "circle" with thumb and forefinger will produce a "bird's eye" appearance as shown in Fig. 25-30.

Unambiguous tests of median nerve intrinsic and extrinsic motor function are shown in Figs. 25-31 and 25-32, respectively.

Sensory Abnormalities

To confirm your diagnosis of a median nerve lesion, you must demonstrate a sensory component. The best place (in terms of consistency of innervation by the median nerve) is the tip of the index finger. It will be easy to remember this after studying Fig. 25-33.

Carpal Tunnel Syndrome

Carpal tunnel syndrome is a neuropathy caused by the entrapment of the median nerve in the carpal tunnel. Differential diagnosis includes thoracic outlet syndrome and cervical radiculopathy. Causes of the syndrome include volar dislocation of the lunate, Colles wrist fracture with acute edema, rheumatoid synovitis, myxedema, and the presence within the carpal tunnel of an embryologically aberrant structure (A. Arem, *personal communication,* 1999).

The Tinel sign is the reproduction of tingling paresthesias over the volar radial aspect of the hand by percussing the volar wrist over the carpal tunnel (with your finger, not with a reflex hammer). Begin over the area of the wristwatch band, moving up toward the "life line"[4] on the palm back to the wristwatch band area, and then a bit radially to the palmaris longus tendon, if you can feel it. The Tinel sign is 65% to 66% sensitive (Phalen, 1970; Spinner et al., 1989). It is not very specific.

The Phalen sign is the reproduction of tingling and paresthesia in the median nerve region by holding the patient's wrist in acute passive flexion for a minute. The significance is the same as the Tinel sign but the sensitivity is 70% to 77% (Phalen, 1970; Spinner et al., 1989).

Sometimes carpal tunnel symptoms can be provoked or aggravated simply by several seconds of direct pressure over the median nerve just proximal to the carpal tunnel (Fig. 25-34).

Median nerve hypesthesia is 43% to 73% sensitive for the diagnosis, and thenar atrophy (Fig. 25-35) is 37% to 40% sensitive (Phalen, 1970; Spinner et al., 1989). A classic or probable distribution of sensory symptoms has a positive LR for carpal tunnel syndrome of 2.4, and an "unlikely" distribution of findings has a negative LR of 0.2 (McGee, 2001). The classic pattern has symptoms in at least two of the first three digits, and no involvement of the palm or dorsum of the hand, although symptoms may be present in the fourth and fifth digits. The probable pattern permits palmar involvement unless confined to the ulnar side. The unlikely pattern has no symptoms in the first three digits (D'Arcy and McGee, 2000). As previously noted, the nerve distribution does not always precisely follow the diagrams (Fig. 25-6).

Quantitative evaluation of median nerve function at the wrist is often performed with electrodiagnostic testing; data from studies of

[4]The palm reader's "life line" is the palmar crease separating the thenar eminence from the rest of the palm.

Figure 25-31 Median nerve intrinsic motor function is best assessed by testing the abductor pollicis brevis, which draws the thumb away in a plane at right angles to the palm. Have the patient position the thumb as shown and resist your effort to push it into the palm. (Photograph by Patti Wylie.)

these techniques have been compiled (AAEM, 1993). Noninvasive testing with the PSSD (Fig. 25-36) has been shown to be as sensitive and specific as electrodiagnostic testing, without pain (Weber et al., 2000), and PSSD measurements are correlated with hand function (Dellon et al., 1997).

Meralgia Paresthetica

The pain of meralgia paresthetica (an entrapment neuropathy of the lateral femoral cutaneous nerve as it exits from the lateral aspect of the inguinal ligament) may be reproduced by compressing the inguinal ligament against the nerve and bone at the medial aspect of the anterior superior iliac spine (McBeath, 1985). (An area of hyperesthesia is also present on the anterior lateral aspect of the thigh.) The sensitivity and specificity of this test is not known; it does not always work, partly because the entrapment tends to come and go and because of the variability of the location of the nerve with respect to the anterior superior iliac crest and the inguinal ligament (Aszmann et al., 1997). The problem may be caused by a tight cincture around the waist; loosening the belt may help. In the military, gun belts are found to cause this condition (J. Dwyer, *personal communication,* 1999).

Figure 25-32 Median nerve extrinsic motor function is tested by having the patient flex the distal phalanx of the index finger against resistance as the PIP and MCP are extended. This is the action of the flexor digitorum profundus. (Photograph by Patti Wylie.)

Figure 25-33 The *arrow* points to the index finger, which cannot be flexed like the other fingers in a case of proximal median nerve compression. (The anterior interosseus branch innervates the flexor pollicis longus and flexor profundus to the index finger.) A median nerve palsy can also cause the benediction hand—not illustrated here—in which the index and middle fingers are extended at the MCP joint, as if to give a papal benediction. One of the doctors is trying to find the anatomic basis for the test in his textbook, whereas the one immediately behind him is apparently testing the sensory division of his own median nerve by thumping his index finger on his head. (*Christ among the Doctors* by Ribera, courtesy of the Kunsthistorisches Museum, Vienna.)

When the tender area can be demonstrated on physical examination, the patient should have a good response to neurolysis of this branch of the lumbosacral plexus (Lee and Dellon, 2000).

Meralgia paresthetica can mimic a lumbar radiculopathy (Kallgren and Tingle, 1993).

Peroneal Nerve

The anterior tibial compartment syndrome develops following vigorous exercise, trauma, or vascular occlusion. It presents as anterior lower leg pain, erythema, and tenderness. Entrapment of the deep peroneal nerve by the swollen muscles causes inability to evert the foot or dorsiflex the foot or toes. There is also sensory loss in the interdigital space between the big and second toes. This is an important syndrome to recognize because without immediate surgical decompression, there can be extensive myonecrosis of the anterior tibial compartment and permanent loss of deep peroneal nerve function (Rorabeck et al., 1972). Peroneal nerve entrapment can cause a pseudoradicular syndrome.

Superficial peroneal nerve compression may occur in young athletes such as runners and dancers, causing pain brought on by walking. The nerve is compressed as it exits the fascia, usually about 10 to 15 cm proximal to the lateral malleolus. There is often a positive Tinel sign at this point. The diagnosis is made by measuring intercompartmental pressures with a wick catheter while the patient is walking on a treadmill.

The deep peroneal nerve can be compressed distally beneath the extensor hallucis brevis tendon because of a ganglion, bony exostosis, tight shoe straps, high-heeled shoes, a crush injury, or a fracture/dislocation of the second metatarsal (Lisfranc fracture) (Dellon, 1990).

The tibialis posterior, the muscle that inverts the foot, is not supplied by the peroneal nerve. Weakness of inversion points to an L5 radiculopathy (Dawson et al., 1983).

Posterior Tibial Nerve (Tarsal Tunnel Syndrome)

The term "tarsal tunnel syndrome" was introduced in 1962 and refers to the area bridging the space between the calcaneus and the medial malleolus, with the roof formed by the flexor retinaculum (Keck, 1962). The contents of the tunnel include the posterior tibial nerve and its branches, the posterior tibial artery, and associated veins. Ankle injuries are the most common cause of the syndrome.

The patient usually presents with burning, tingling, or numbness in the plantar aspect of the foot, most frequently in the toes or

Figure 25-34 A patient with carpal tunnel syndrome may describe paresthesias over the median nerve distribution after several seconds of pressure over the nerve just proximal to the carpal tunnel. (Photograph by Patti Wylie.)

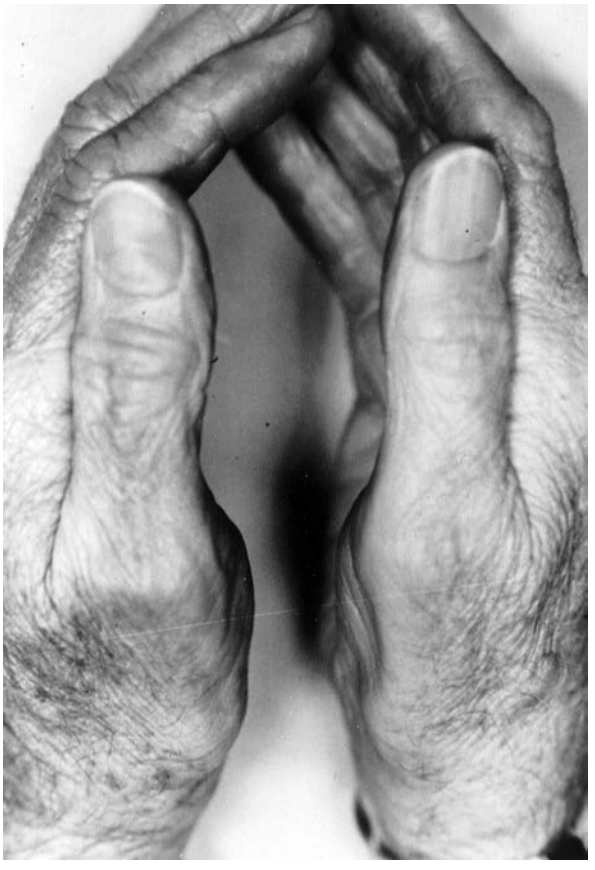


Figure 25-35 Thenar atrophy due to carpal tunnel syndrome. (Courtesy of *Consultant Magazine,* Cliggott Publishing Group of CMP Healthcare Media, Darien, CT, and Dr Thomas E. Weiss.)

beneath the metatarsal heads. Symptoms may extend to the heel; occasionally, heel pain is the presenting complaint. Physical examination shows a Tinel sign over the course of the posterior tibial nerve and over the medial and lateral plantar nerves as they exit from their respective distal tunnels. The former is referred to the big toe and the latter to the little toe. Diminished vibratory sense and two-point discrimination may be detectable, compared with the other side. In advanced cases, atrophy of the abductor hallucis brevis and clawing of the toes, often mistaken for hammer toes, may be seen.

Note that the medial calcaneal nerve has great variability. It can become entrapped in the tarsal tunnel, the lateral plantar tunnel, or its own calcaneal tunnel. Diagnosis is made by careful sensory testing, as with the PSSD. If abnormal sensibility is also present in the big toe, suspect tarsal tunnel syndrome. If abnormal sensibility is present bilaterally and also in the peroneal nerve distribution to the top of the foot, a peripheral neuropathy is likely (Dellon et al., 2002).

The tarsal tunnel syndrome may be misdiagnosed as plantar fasciitis, Morton neuroma, or diabetic neuropathy alone. Remarkably, diabetics with long-standing symptoms have responded well to surgical release (Mackinnon and Dellon, 1988).

Other Misdiagnoses of Lower Extremity Entrapment Syndromes

Of approximately 4,000 patients with leg pain referred for suspected lumbar radiculopathy, 36 had peripheral nerve entrapments as the sole cause of their leg pain. Involved nerves included the femoral, sciatic, obturator, saphenous, peroneal, and tibial nerves. Local tenderness was the most helpful physical sign. Patients with piriformis syndrome (*vide supra*) may have a history of blunt gluteal trauma (Benson and Schutzer, 1999). Peripheral entrapment needs to be ruled out before subjecting patients to lumbar surgery (Saal et al., 1988).

Saphenous nerve entrapment neuropathy may also be misdiagnosed as damage to the medial collateral ligament of the knee. The former can be distinguished when pressure high above the point of ligamentous attachment also causes pain, which radiates all the way down the medial surface of the leg (Koppel and Thompson, 1960).

Precise diagnosis makes it possible to offer surgery that can relieve symptoms while avoiding surgical procedures that are misdirected.

Figure 25-36 Testing sensory function of the median nerve on pulp of the index finger with the pressure-specified sensory device (PSSD). The threshold for detecting touch by one point is being tested here. The patient presses the button held in her right hand as soon as she detects the stimulus. (Photograph by Patti Wylie.)

Appendix 25.1

Myopathy: Answer to Question (in an Exercise for the Student)

Given the fact that the myopathy is not generalized and that there is no atrophy at a time when the pelvic girdle is afflicted, most of the myopathies have already been ruled out. His baldness should not suggest myeloma dystrophica because this typically causes temporal baldness, not alopecia totalis. Furthermore, his masseter muscle seems well preserved as does the temporalis. Alcoholic myopathy should not be localized to the pelvic girdle nor should that of hypothyroidism. Chronic thyrotoxic myopathy should also show more atrophy of the shoulder girdle and so perhaps should polymyositis. Thyrotoxic periodic paralysis, and for that matter the other periodic paralyses, including myasthenia gravis, should not so selectively affect the pelvic girdle. The patient does not look cushingoid, and there is no evidence that corticosteroids were known to the Olmecs. I will discount sarcoid myopathy, central core myopathy, and nemaline myopathy on the basis of rarity.

Do you see how much easier this analysis would be if we could just elicit a history?

In summary, we have an adult male with pelvic girdle disease, no diffuse atrophy, perhaps even some hypertrophy. I would diagnose this as a case of Duchenne pseudohypertrophic muscular dystrophy, a mild sex-linked variant. (It would have to be the mild variant for the patient to reach this age without yet showing atrophy of the biceps and brachioradialis muscles.)

If you diagnosed myositis ossificans, give yourself a raspberry.

Appendix 25.2

Answer to Question in Fig. 25-2 Legend

The resident said that the bulge shown in Fig. 25-2 was a bicipital head whose tendon insertion had ruptured. The attending said it was a herniation through an aponeurotic defect, noting that the patient could not recall the onset. The resident rebutted, saying that the patient often could not remember things and seemed to have a chronic organic brain syndrome due to alcohol, either directly or indirectly through effects on the liver (remember the spider?). If you diagnosed either one of these, your answer is as good as anyone else's. Although one aims for diagnostic closure, sometimes the information that is sought does not justify the risk or cost required to obtain it, and we go without a final answer.

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CHAPTER

26

The Neurologic Examination

The chief features of interest in the case, to which the attention of the Society is directed, are that during life the existence of a tumour was diagnosed in the brain, and its situation localized, entirely by the signs and symptoms exhibited without any external manifestations on the surface of the skull.

—*Medico Chirurgical Transactions*, published by the Royal Medical and Chirurgical Society of London, Vol. 68. J. E. Adlard, London, 1885

Points to Remember:

- Determine the level at which a neurologic problem originates: brain, spinal cord, nerve root, peripheral nerve, or muscle; then localize it more precisely.
- Careful attention to the cranial nerves, especially in elderly patients with comorbid conditions, can prevent dangerous misdiagnoses.
- An astute observer can make a number of neurologic diagnoses simply by observing (and listening to) the gait.
- Distinguish aphasia, a disorder of language, from disorders of articulation, and characterize the aphasia as fluent, nonfluent, or conduction.
- In any patient presenting with a movement disorder, a careful drug history is mandatory.
- Examiners will miss early or mild weakness if they test only grip strength and a few big muscle groups.
- Check deep tendon reflexes for strength, symmetry, and delay.
- Careful sensory testing can identify treatable conditions, such as entrapment neuropathies, at an earlier stage, and can also identify malingerers.
- Even mild head trauma can cause consequences such as subdural hematoma, especially in patients with predisposing conditions such as coagulation disorder, and manifestations may be delayed.
- The most common cause of paranoid ideation on the general medical service is acute organic brain syndrome, especially in patients with partial sensory deprivation.

Overview

On Topography

I had to report on papers along with everyone else, and the first one I was assigned was on the effect of pressure on cells—Harvey chose that topic for me because it had something that had to do with physics. . . .

The next paper selected for me was by Adrian and Bronk. They demonstrated that nerve impulses were sharp, single-pulse phenomena. They had done experiments with cats in which they had measured voltages on nerves.

I began to read the paper. It kept talking about extensors and flexors, the gastrocnemius muscle, and so on. This and that muscle were named, but I hadn't the foggiest idea of where they were located in relation to the nerves or to the cat. So I went to the librarian in the biology section and asked her if she could find me a map of the cat.

"A *map* of the *cat* sir?" she asked, horrified. "You mean a *zoological chart!*" From then on there were rumors about some dumb biology graduate student who was looking for a "map of the cat."

When it came time for me to give my talk on the subject, I started off by drawing an outline of the cat and began to name the various muscles.

The other students in the class interrupted me: "We *know* all that!"

"Oh," I say, "you *do*? Then no *wonder* I can catch up with you so fast after you've had four years of biology." They had wasted all their time memorizing stuff like that, when it could be looked up in fifteen minutes.

(Reprinted from "*Surely You're Joking, Mr. Feynman!*," *Adventures of a Curious Character*, Richard P. Feynman, as told to Ralph Leighton. Edited by Edward Hutchins. By permission of W. W. Norton & Company, Inc. Copyright © 1985 by Richard P. Feynman and Ralph Leighton.)

A Pedagogic Note. Although memorization is not in vogue, and is in fact often deplored, its usefulness (indeed necessity) is easy to demonstrate in many contexts. It is obviously a waste of time to memorize a collection of useless data. But it is a terrible handicap not to have certain fundamentals in one's random access memory, both as a skeleton on which to organize other data and as a tool for performing frequent mental tasks rapidly. Those who do not memorize their "math facts" will never develop the habit of quantitative thinking and mental arithmetic that characterizes good scientists or even be able to add up a restaurant tab if the computer is down. Those who do not at some point memorize the periodic table of the elements (perhaps excluding the transuranics) will not automatically recognize likely chemical reactions. Those who do not know some basic anatomy and neuroanatomy will not be able to perform a competent orthopedic or neurologic evaluation.

Richard Feynman, a physicist, did not need to memorize any anatomy. You do—unless you plan to specialize narrowly in diseases of some internal organ and refer all other ailments to another physician. At least, you need to know the basic plan and a minimum number of key facts, if not all the details. Always keep in mind the overall "map" of the nervous system, and be sure to ask yourself whether the patient's problem originates in the brain, spinal cord, nerve root, peripheral nerve, or muscles. Then narrow it down further: which area of the brain, which part and level of the spinal

cord, which nerves, which muscles? Concentrate first on learning the tests that are most diagnostic of common lesions and fill in more details as you see more patients.

A Note to the Sophomore. By now you have probably noted some discrepancies between the sequence of examination taught in your school and the one offered here. In a little while, you will realize that there are some potential conflicts even between the latter and the outline presented in Chapter 4 (e.g., many of the cranial nerves were already examined earlier *en passant*). Even within this chapter there are inevitably arbitrary divisions. For instance, the vestibular and cerebellar systems really should go together. The cerebellum and the posterior (dorsal) columns of the spinal cord might be considered together. But in fact, signs of disease in these three systems are actually in three different sections of the work. Similarly, some of the tests of gaze are not considered with the skilled movements but rather with the cranial nerves whose testing might first reveal such gaze abnormalities. The principle of medicine is clear in all these situations: If you have already learned one order of examination, stick with it. Consistency is more important than the specific virtues of any necessarily arbitrary linear system of organization.

You have also noticed that much of the neurologic examination is performed while doing the musculoskeletal examination. It is not practical to have the patient constantly shift from one position to another. You organize the examination by body region and position, whereas your thinking (and certainly this book) may be organized by the system.

Dr Michael Schlitt of Renton, Washington, states that the most useful thing he learned was to start at one end and move toward the other. It is his preference, when doing a complete neurologic examination, to start with the feet and move north—although he does not record the examination in that order. Physicians more commonly start at the head, in this author's experience, but each one develops a routine that becomes familiar and efficient.

At the beginning of a neurologic examination, Dr Lawrence Huntoon of Lake View, New York, places all his instruments in order on the table and puts each one away after using it. This is comparable to that of a pilot going through a very specific checklist each and every time before taking off.

Cranial Nerves

Cranial Nerve I

The testing of the first cranial nerve is discussed under the regional examination of the nose in Chapter 12. Although performed regionally, the results are recorded under the neurologic examination in the case record.

Cranial Nerves II and III

The testing of vision, including related pupillary signs, is presented in detail in Chapter 10.

Cranial Nerves III, IV, and VI

Pupil (Cranial Nerve III)

Horner syndrome, or the sympathetic-ocular syndrome, consists of anisocoria (with the homolateral pupil smaller), enophthalmos, ptosis, and anhidrosis with decreased pilomotor response. It is frequently seen in Pancoast syndrome (see Chapter 10).

Anisocoria is also discussed in detail in Chapter 10.

Extraocular Muscles (Cranial Nerves III, IV, and VI)

A Difficult Self-test

The extraocular muscles are discussed in Chapter 10, but it is time for a review. The next few cases are difficult but very revealing. Go slowly through the questions that follow. Make good clinical observations and reason carefully from your data.

The answers to the questions will be found at the end of this section so that you will not inadvertently glance at them.

1. Look at Gregory (Fig. 26-1). His eyes are in the primary position. (We refer to the eyes as being in the primary position when the patient is following instructions to look directly at the examiner.) What is wrong with Gregory? Write down your full answer.
2. Moses (Fig. 26-2A) is apparently being seen in the dermatology clinic for a keratotic problem. For the time being, ignore that. (a) If the photograph was taken with Moses looking at you in the primary position, what is the most likely diagnosis? (b) Before turning to the end of this section for the answer, what diagnosis would you make if the picture was taken while Moses was watching your finger move from the midline to his left (your right)?
3. What is wrong with the virgin in Fig. 26-3A? She is not exactly in the primary position, but rather she is gazing down toward your right hand. However, if you ask her to look at you, she will do so but without moving her head. (If you have got the correct answer by now, either you have studied Chapter 10 or you should be writing books like this instead of reading them.)

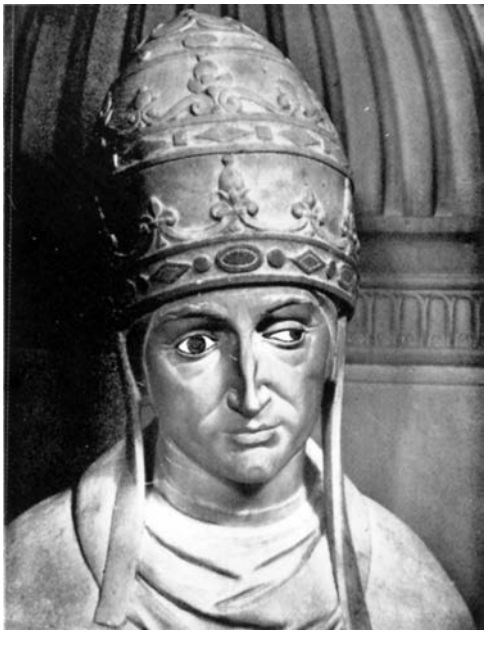


FIGURE 26-1 Self-test (see text). (Saint Gregory, by Michelangelo, from the Piccolomini altar.)

A B

FIGURE 26-2 Self-test (see text). (Monument of Pope Julius II. Moses, by Michelangelo.)

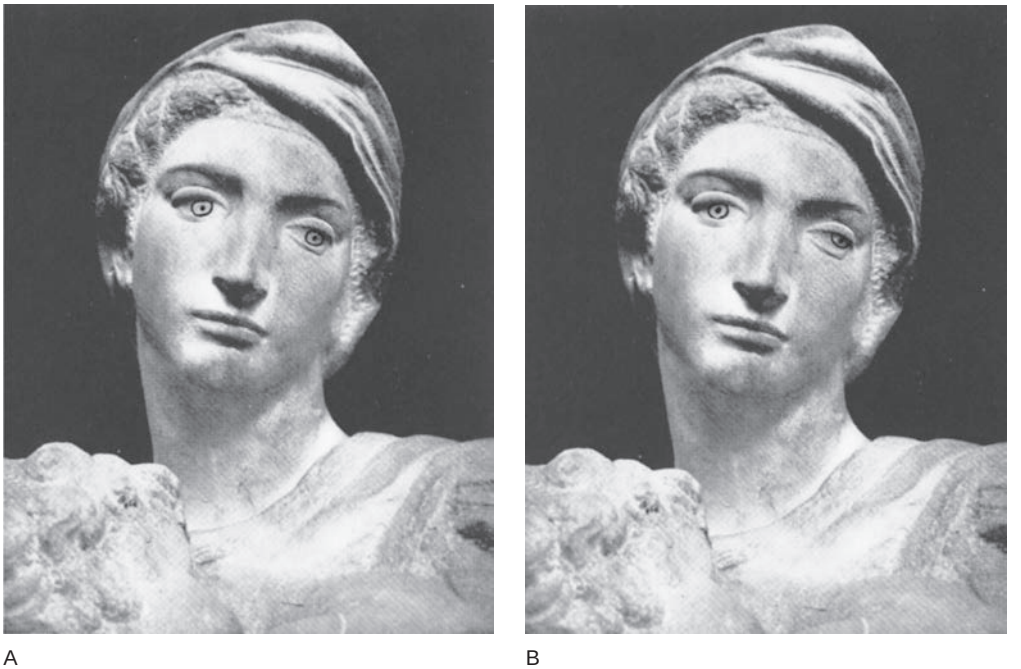
4. Look at the eyes in Fig. 26-4. (a) If this is the primary position, what are the *two* most likely diagnoses? (b) If you were checking the extraocular movements, and the patient was supposed to be looking to his right (to your left), what would be the two most likely diagnoses?

Answers. To answer these questions, you need to know the cardinal directions of gaze, shown in Fig. 26-5A. These are simplified, excluding the components of external and internal rotation. A more complete picture is given in Fig. 26-5B.

1. If you said oxycephaly, you are 100% wrong; that is just his hat. Go back and look at the eyes. Gregory has a left third cranial nerve oculomotor palsy. Any other answer is wrong. This cannot be a coincidental palsy of the individual muscles innervated by cranial nerve III on the left side.

   Why not? (The answer to this question explains why all other explanations are incorrect.) Go back and look at the picture again.

   Did you notice the ptosis on the left but not the right? This clearly implicates cranial nerve III. If Gregory were suffering only



A B

FIGURE 26-3 Self-test (see text). The Bielschowsky sign. (The Medici Virgin, by Michelangelo.)

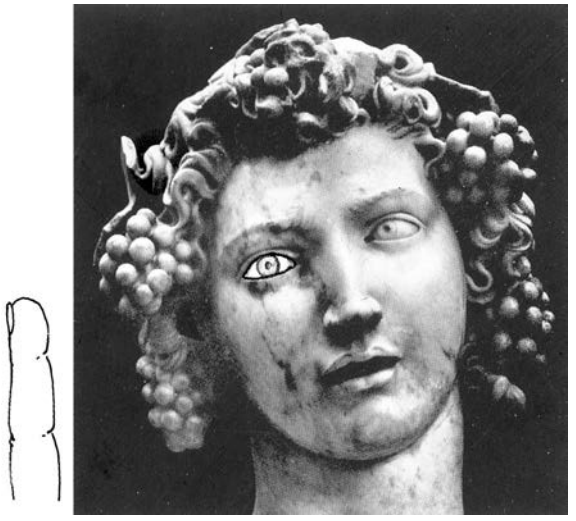


FIGURE 26-4 Self-test (see text). (Bacchus, by Michelangelo.)

from disease of the individual oculomotor muscles (as unlikely as William of Occam[1] would consider that), there would be no ptosis.

The left eye looks laterally because the lateral rectus, which is innervated by cranial nerve VI, is unopposed by the medial rectus, which is innervated by cranial nerve III.

The superior oblique muscle, which is innervated by the trochlear nerve, is unaffected. Although it is used for turning the eye down and in, it is not of much use without the superior rectus, inferior rectus, and inferior oblique muscles, all of which are lost here, being innervated by cranial nerve III.

2. (a) If the appearance in Fig. 26-2A occurs in the primary position, Moses has a left medial rectus muscle paralysis. Again, the unopposed lateral rectus can pull the eyeball laterally when it is not opposed by the medial rectus. (If you got that wrong, go back and do both questions over before reading on because you probably got the second one wrong also.) *Note*: This is probably not caused by an oculomotor nerve lesion as there is no ptosis. There is also no pupillary dilatation, but in the oculomotor nerve palsy secondary to a metabolic disorder such as diabetes (in contrast to structural lesions such as a posterior communicating artery aneurysm), the pupil is generally spared.

(b) If the appearance in Fig. 26-2A is seen while Moses is following your finger to his left, the single lesion most likely to explain the finding is a right medial rectus palsy because he is unable to pull the right eyeball around so that it will point toward your finger, although the left has moved normally.

This case illustrates why one must always describe the examination carefully: The same appearance can indicate disease in three different places, depending upon what instructions the patient is following when the appearance is observed.

Yes, *three* different places. There is one other lesion that could produce the appearance of Fig. 26-2A while gazing to the left (your right). But you could only detect it by testing the cardinal directions of gaze. What if you saw the appearance in Fig. 26-2B when Moses gazed to his right (your left)?

It now appears that each lateral rectus can work. A patient with these findings would look normal when asked to look directly at the examiner because each medial rectus also works. This, then, is a disturbance of conjugate gaze called *bilateral internuclear ophthalmoplegia*. (This is to be distinguished from *internal* ophthalmoplegia, which refers to paralysis of the pupil, and is usually used in distinction to *external* ophthalmoplegia or impaired mobility of the eye.) *Unilateral* internuclear ophthalmoplegia occurs with gaze palsy only to one side.

Internuclear ophthalmoplegia is important to know about for two reasons: (a) If you are not aware of it, you can miss it. (b) It is, like other disorders of conjugate gaze, not a peripheral muscle or nerve sign but a central nervous system sign. Bilateral internuclear ophthalmoplegia (Moses, Fig. 26-2A, B) is often seen in multiple sclerosis (MS); unilateral internuclear ophthalmoplegia often occurs after vascular accidents to the medial longitudinal fasciculus (MLF). Other causes of internuclear ophthalmoplegia include infections, cervical involvement in rheumatoid arthritis (Menezes et al., 1985), paraneoplastic disease, and other degenerative, nutritional, or metabolic processes (Brazis and Lee, 1999).

Neuroanatomy Review. Internuclear ophthalmoplegia is caused by a lesion in the MLF, which connects the abducens nucleus on one side with the oculomotor nucleus on the other. A unilateral MLF lesion causes inability to adduct the ipsilateral eye and also a monocular nystagmus of the contralateral eye when the patient looks *away* from the side of the lesion. *An MLF lesion is distinguished from a lesion of the medial rectus by the patient's ability to converge*. The corticobulbar fibers subserving convergence do not travel in the MLF.

3. This patient has a right trochlear nerve palsy or a paresis of the muscle that it innervates, the right superior oblique. The patient's head is tilted away from the lesion or in the direction in which the affected muscle moves the eye so as to minimize the double vision. This is the natural position of about 50% of the patients with this exceedingly rare problem (Younge and Sutula, 1977). (The head tilt may be documented in childhood and adult photographs.) Even if you did notice the head position, you would have to make the definitive diagnosis by going through the six cardinal motions of gaze. If you ask the patient, you will probably discover that she finds it somewhat difficult to walk down stairs, as diplopia is maximal on looking down.

[1] William of Occam was a philosopher whose "razor" was a logical device used to cut through intellectual problems that have multiple solutions. Basically, it said that the most likely solution is the simplest. Or, a single explanation that explains all findings is more likely to be true than multiple explanations for the same things. In medicine, this means that the least complex diagnosis is most likely to be correct. Stated another way, it tells us never to make two diagnoses when one would explain all the findings.

Now that our technology has developed to the point that we are able to keep patients alive with their diseases (and the attendant signs and symptoms) for prolonged periods, the rule must be modified. It should state that signs and symptoms not yet explained by previous known diagnoses are best explained by a single additional diagnosis, as opposed to two or more additional diagnoses. Most good clinicians understand this intuitively.

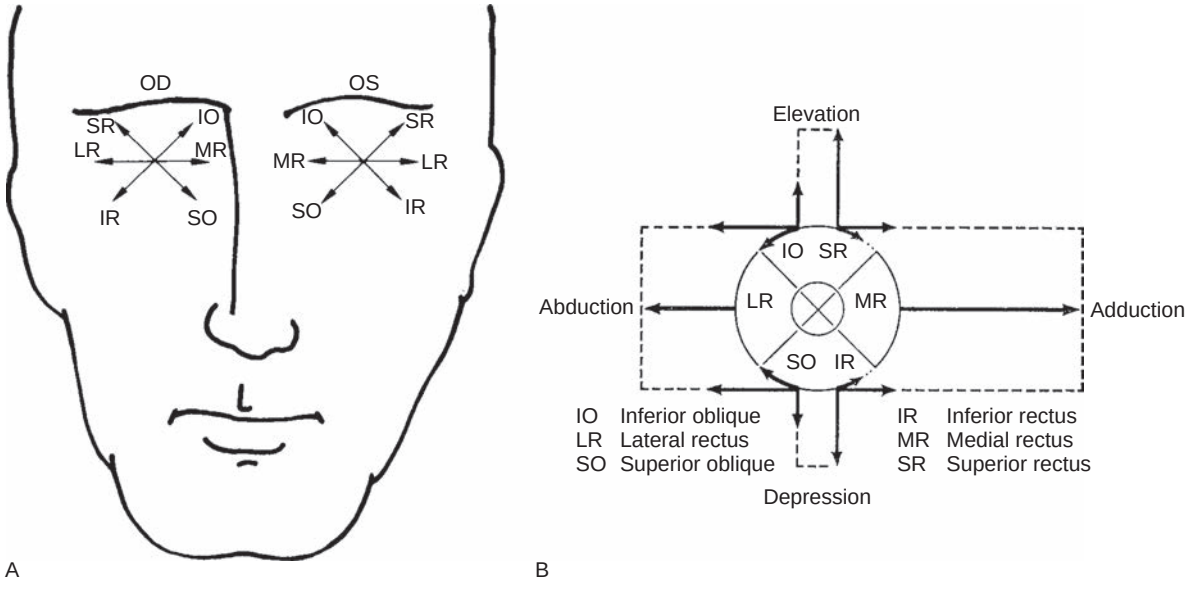


FIGURE 26-5 **A:** Cardinal directions of gaze and functions of the extraocular muscles. (From Younge BR, Sutula F. Analysis of trochlear nerve palsies: diagnosis, etiology, and treatment. *Mayo Clin Proc.* 1977;52:11–18, with permission.) A suggested mnemonic: IOUi (I owe you one: the inferior oblique pulls the globe up when turned in). **B:** Scheme to illustrate the action of the extraocular muscles. Note that only the medial and lateral recti operate in a single plane. Each of the other muscles have three components of action: adduction or abduction; depression or elevation; internal or external rotation. The actions are influenced by the position of the eyeball. When the globe is rotated outward 23 degrees, the superior rectus is a pure elevator, and the inferior rectus a pure depressor. The more the globe is turned inward, the more these muscles act as internal and external rotators. When the eye is turned inward, the inferior and superior oblique act as an elevator and a depressor, respectively. The various muscles act in concert with each other so that their conflicting tendencies normally cancel out to give a harmonious result; for example, when the two obliques aid the lateral rectus in abduction, their vertical and rotatory forces cancel each other out. IO, inferior oblique; MR, medial rectus; SO, superior oblique; SR, superior rectus; LR, lateral rectus; IR, inferior rectus. (Modified from Brain L, Walton JN. *Brain's Diseases of the Nervous System*. London: Oxford University Press; 1969, with permission.)

The cardinal positions of gaze (Fig. 26-5) would reveal the lesion as follows: When the patient looked straight ahead, the right globe would show some slight but definite upward deviation. This would implicate either the right superior oblique or right inferior rectus (the only two muscles that pull the right globe down). The upward deviation of the right globe would increase when the patient looked to the left (inward) but would decrease when she looked to the right (outward). This maneuver would exclude the right inferior rectus and would implicate the right superior oblique. (See the legend to Fig. 26-5B.)

The girl in Fig. 26-3B is the virgin's twin sister. She also has a cranial nerve IV (or superior oblique muscle) paralysis but on the left side. When she came in, her head was tilted toward her right. The present figure shows what happens when you tilt her head (examiner's hands not shown) out of its natural position, toward the side of the lesion. The sign is very subtle but definite. Look carefully at the illustration and describe what has happened.

The left pupil and iris have floated up. Notice that you can now see a little bit of sclera and all of the limbus on the left, but not on the right.

4. (a) In the primary position (i.e., if the left eye is the abnormal one), this would be a left lateral rectus muscle paralysis or a left cranial nerve VI lesion. The left eye is turned inward because the sixth cranial nerve innervates only the lateral rectus, and all of the other unopposed muscles, especially the medial rectus, are pulling the eyeball in.
(b) If, on the other hand, you were testing the extraocular movements (with your finger positioned as shown), this would probably be a right lateral rectus paralysis (or a right cranial nerve VI lesion) because the patient is unable to bring his right eyeball laterally.

Cranial nerve VI is the most common cranial nerve to be afflicted, presumably because it travels the longest course.

An Anatomy Review

For the Guru. If Fig. 26-5 is to be less of a mystery, you need to be able to visualize the action of the extraocular muscles rather than simply memorize the cardinal directions of gaze. To this end, you need to know the muscle insertions with respect to the equator and axis of the eyeball. Study Fig. 26-6; you may need to move the book around to help visualize the globe from various directions. It also helps to know that whereas all of the extraocular muscles have their origin from the common tendinous ring at the back of the orbit, the tendon of superior oblique passes through the trochlea in the medial side of the roof of the orbit before inserting on the globe, changing the direction of the muscle pull by 60 to 90 degrees.

Double Images

Thus far, we have concentrated on how the patient's eyes look to the examiner. From the appearance of the images to the patient, as with the red glass test (*vide infra*), one can also tell which muscle is weak, even if the palsy is so slight that the examiner does not perceive a defect in the ocular movements. If colored glass is not available, an intelligent and cooperative patient can usually distinguish the images by noticing which disappears when each eye is covered completely (Brain and Walton, 1969).

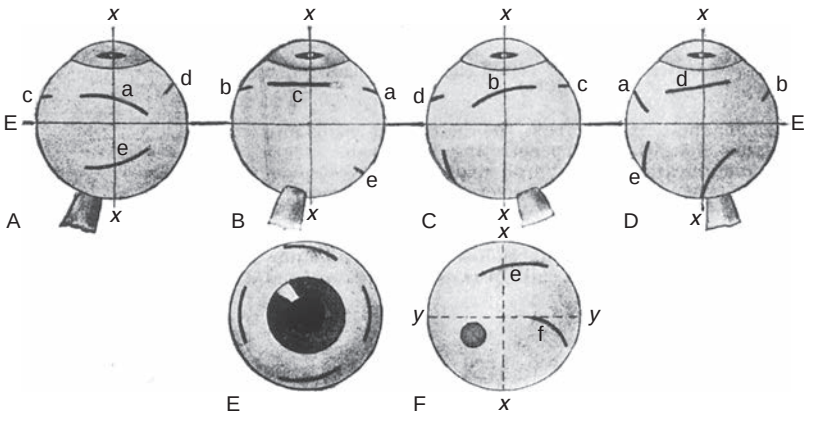


FIGURE 26-6 Insertions of extraocular muscles on the sclera of the right eye. **A:** View from above. **B:** View from nasal side. **C:** View from below. **D:** View from temporal side. **E:** View from the front. **F:** View from behind. a, superior rectus; b, inferior rectus; c, medial rectus; d, lateral rectus; e, superior oblique; f, inferior oblique; EE, equator; xx axis. In **F**, yy, horizontal meridian; xx, vertical meridian. (From Baker F. Eye. In: Buck AH, ed. *Reference Handbook of the Medical Sciences*. Vol. IV. New York: William Wood and Company; 1907:69, with permission.)

The Red Glass Test

A Method

1. Place a *red glass* (or cellophane) over the patient's right eye. Either eye could be used, but by convention it is generally the right.
2. Hold a flashlight at a distance of 1 m in each of the cardinal directions of gaze. Ask the patient to state the position of the red and the white images. Determine the direction in which the two images are farthest apart, and which one is more peripheral.
3. Plot the most deviant position of the false image—the more peripheral one—on the cardinal directions of gaze chart as in Fig. 26-7. Be sure to identify the correct eye from the color of the false image.

A Caveat. Be sure to keep the flashlight beyond the point of convergence. (Testing within the point of convergence is the most common cause of diplopia, with or without the red glass [S. Horenstein, *personal communication*, 1988], because neither eye can aim at the target, and a physiologic diplopia is thus induced. Try it on yourself: Hold your forefinger in front of your nose. As it is moved from say 12 in. away to 2 in. away, attend to how many images you see.)

Explanation

1. *The direction in which the separation between the images is maximum is the direction of action of the paretic muscle*. For example, if the greatest separation occurs on looking to the left, either the left lateral rectus or the right medial rectus is weak.
2. *The image formed by the paretic eye is the one projected most peripherally*. To understand why this is true, it may help to draw a picture. In the normal eye, the image falls on the macula; that is, the crosshairs are on the target. In the paretic eye, the image falls on the retina some distance from the macula. Thus, it will be less distinct (although the patient may not be able to perceive the difference) and will appear to come from the corresponding (opposite) visual field. For example, if the red image is farther to the left as the patient looks to the left, it is the right medial rectus that is not functioning properly. (The image falls on the left macula but on the temporal portion of the right retina, or in the right nasal visual field, to the patient's left.)

With the other muscles, the situation is much more complicated because each has three vectors of motion. The end result is that the false image caused by paresis of a single muscle is found in the quadrant of the visual field indicated in Fig. 26-7, which corresponds to the cardinal direction of gaze principally served by that muscle. With vertical diplopia secondary to a problem in a cranial nerve or the brain, the situation is very complex and may require referral to a specialist. A detailed exposition can be found on the Internet by searching for "Jeff Mann's EM Guidemaps, Diplopia."

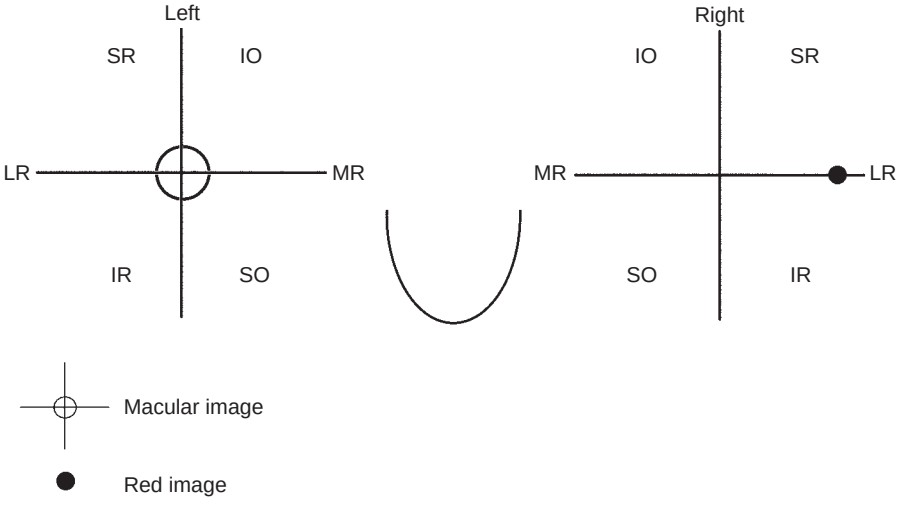


FIGURE 26-7 View through the patient's eyes. The open circle represents the macular image in the normal eye. The false image due to a paretic muscle would be seen within the indicated quadrant. The closed circle represents the false image seen by a patient with a paralysis of the right lateral rectus. (Courtesy of Dr Lawrence Huntoon, with permission.)

Dr Lawrence Huntoon states that three simple rules on diplopia due to cranial nerve palsies are generally accurate:

1. With a sixth nerve palsy, diplopia is greatest when looking to the affected side.
2. With a third nerve palsy, diplopia is greatest when looking up and to the opposite side.
3. With a fourth nerve palsy, diplopia is greatest when looking down and to the opposite side.

Case Report. A physician, on noting that "things just did not look right," ascertained that she had transient diplopia on gaze to the right (i.e., upon looking to the right, there were two images that gradually came together). Performing the red glass test on herself, with the red glass over the right eye, she observed that there were two images when the flashlight was held to the right, with the white image more peripheral, but there was only one image when it was held to the left. Having thereby persuaded herself that she was not imagining things, she made a sketch of her findings (Fig. 26-8) and consulted a neurologist.

Self-study Question. How would you interpret the test? (Answer is in Appendix 26.1.)

A Nonneurologic Cause of Diplopia or Ophthalmoplegia

There are numerous case reports of diplopia or complete ophthalmoplegia, with or without ptosis, in association with statin drug use (see Chapter 10) (Fraunfelder and Richards, 2008).

Paralysis of Conjugate Movements (Gaze)

Horizontal Gaze Palsy

When the patient is unable to shift his gaze to a particular direction, or when the eyes move together (conjugately) in an unexpected manner, the cause is inevitably central in origin. For instance, in acute cerebral cortical disease, especially involving a frontal lobe, the eyes conjugately gaze toward the side of the lesion and cannot, on command, move to the opposite side, although they will move together to the extent that they can move. On the other hand, with destructive lesions in the parietal lobe or below the cerebral cortex, as in the pons, the eyes tend to look away from the side of the lesion. The patient is unable to look in the other direction on command, though the motions that can occur are conjugate. In other words, pontine and parietal gaze palsies tend to "push" the eyes to the opposite side, whereas frontal gaze palsies tend to "pull" the eyes to the same side. With irritative lesions, the rules are reversed.

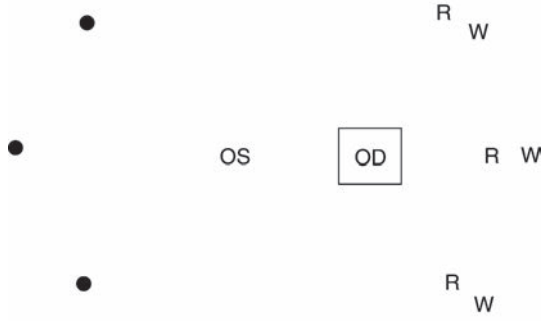


Figure 26-8 Diagram of results of red glass test from the chart of the patient described in the case study. R is red image, W is white image, and circles are for superimposed images. *Square* indicates red glass, which was placed over the right eye. OD, right eye, OS, left eye. The neurologist observed some nystagmus in the right eye on gaze to the right. See Appendix 26.1.

Gaze preference refers to conjugate deviation of a spontaneous nature that is inconstant. That is, the eyes can be made to cross the midline, as during caloric stimulation, thus ruling out brainstem disease, but the eyes customarily look at one and only one side.

A common case of a persistent gaze preference is a lesion in the visual cortex of the occipital lobe. A left homonymous hemianopsia causes a gaze preference to the right (L. Huntoon, *personal communication*, 1998).

If there were bilateral cortical infarcts involving the frontal areas controlling the initiation of horizontal gaze, a patient could lose the ability to track on command but would retain the ability to track by reflex. That is, the patient would be unable to follow the instruction "look to the right," but would be able to look to the right in the course of following the examiner's finger or sometimes the examiner's head if the latter was used as a tracking target. Metabolic disturbances can do this, and probably other lesions could interrupt the cortical projections to the midbrain centers controlling the eye movements. However, the most common cause of this phenomenon on a general medical ward is simply a patient who is too fatigued or confused to cooperate with the tracking or looking command, but who will reflexly follow the physician's head (as a tracking target) while staring into the physician's eyes.

Parinaud Syndrome

Parinaud syndrome is paralysis of conjugate vertical gaze due to damage near the posterior commissure. In some cases, downward conjugate gaze is preserved but upward conjugate gaze seems almost always to be lost. If this syndrome is found in a sexually precocious prepubertal boy, make a diagnosis of pinealoma.

An Eponymic Distinction. This Parinaud syndrome is not to be confused with Parinaud conjunctivitis, which is the same as Parinaud oculoglandular syndrome. The latter refers to a preauricular lymph node in combination with an ipsilateral (but unilateral) conjunctivitis (see Chapter 8). This is mentioned to point out the peculiar principle that a majority of clinical syndromes have been described by a small minority of physicians.

For the Advanced Student. Some authorities consider the neurologic Parinaud syndrome to be a triad including, in addition to supranuclear paralysis of upward conjugate gaze, defective convergence and (nonconstricted) pupils that react more briskly to accommodation than to light (Maciewicz, 1983). These latter two signs point to the same midline structures as the first, so the distinction between the two definitions is not always important.

For the Intern. Does the patient have some sort of myopathy or peripheral neuropathy that prevents the eyeballs from moving upward, or is he unable to look up *on command*? One trick is to have the patient track upward (e.g., ask him to follow your finger with his eyes). Some patients can track but cannot voluntarily look up. A second trick is to use the vertical version of the oculocephalic (doll's eye) reflex (sign, test), discussed later. If passive head tilting downward causes the globes to rotate superiorly (in relation to the skull) as the patient fixes his gaze on some object, one has demonstrated (a) an absence of a mysterious myopathy or

a combination of peripheral neuropathies inhibiting upward gaze and (b) that the projections from the midbrain loci controlling eye movements have become severed from their higher (frontal) projections.

For the Resident. Although Parinaud syndrome is most famous as a sign of pinealoma, hydrocephalus is probably its most common cause (Chattha and Delong, 1975).

For the Guru. What Parinaud actually described is a triad of disturbances of the three components of normal convergence. These signs taken together he referred to as "essential." Additionally, he recognized a second form called "combined," in which the "essential" form was combined with paralysis of elevation and/or depression (Parinaud, 1886). Thus, it is quite possible for someone to have Parinaud syndrome according to Parinaud's definition and not have a paralysis of upward conjugate gaze. The essential Parinaud syndrome is a peculiar triad, the individual features of which are quite inconstant:

1. Paralysis of convergence, indicated by the examiner's recognition that convergence does not occur and/or by a peculiar subjective diplopia of variable salience.
2. Paralysis of accommodation in one eye, both eyes, or neither eye (Maciewicz, 1983). (See Table 10.7.)
3. Pupillary reflexes exactly reverse to those of the Argyll Robertson pupil (Parinaud, 1886). Note that this can also occur in Wernicke encephalopathy (see Chapter 10).

In the same paper, Parinaud described a number of other gaze palsies. Most intriguing to the medical historian is the fact that not a single patient reported in Parinaud's original paper (Parinaud, 1886) had a pinealoma.

For the Scholar. By reading the paragraphs in this section in reverse sequence, much as an archaeologist examines the superimposed levels of civilization in a slit trench, from the oldest at the bottom to the newest at the top, one can observe the transmogrification of an original syndrome (Parinaud, 1883). Such distortions are euphemistically referred to as "the advance of modern science."

For the Clinician. Parinaud syndrome due to trauma may be distinguished from Parinaud syndrome due to pinealoma in that the former has a segmental palsy of the iris in response to light stimulation but the latter does not (Thompson, 1978).

Cerebellar Hemorrhage

The diagnosis of cerebellar hemorrhage is discussed here because of the historic importance attributed to its eye signs, especially the conjugate gaze palsies (Table 26.1). Note that the cerebellar hemorrhage has a wide variety of neurologic signs and symptoms by which it may be distinguished from other intracranial hemorrhages. The most common eye finding is an abducens nerve palsy, which also occurs with a number of other lesions.

Cerebellar hematoma often presents as a neurosurgical emergency. General physicians often have difficulty making the diagnosis and the appropriate referral. The presentation is frequently acute and characterized by the triad of headache, vomiting, and ataxia. Progression to gaze palsies, long-tract signs, and respiratory difficulties can occur rapidly. A cerebellar hematoma that is 3 cm or larger on computerized tomography almost always causes brainstem compression and requires immediate surgical evacuation. A large cerebellar infarct can mimic a hematoma and may also require prompt surgical decompression (M. Faria, *personal communication*, 1998).

The sign of "ocular bobbing" (referred to in Table 26.1) is abrupt spontaneous downward jerks of the eye with a slow return to the midposition *plus* paralysis of spontaneous and reflex horizontal eye movements (Bosch et al., 1975). It is actually a sign of compression of the pons and is not a "cerebellar sign" per se. It also may occur with obstructive hydrocephalus, pontine hemorrhages, and, occasionally, metabolic encephalopathy (L. Huntoon, *personal communication*, 1998).

In the mid-1960s, it was believed that one could, and must, make the emergent diagnosis of cerebellar hemorrhage based upon the eye findings. However, the eye signs are not as necessary to the diagnosis as once thought (Heiman and Satya-Murti, 1978).

Newer eye signs are not included in the table (e.g., spontaneous unilateral eye closure [Messert et al., 1976], which occurs because the patient develops an ipsilateral seventh nerve palsy due to displacement of the brainstem by the hematoma and then attempts to avoid diplopia by closing the only eyelid still under his control, the contralateral one. The eye on the side of the hematoma and seventh nerve palsy is the one that remains open).

For the Very Advanced Student. The maximal predictive value of a positive test is about 85% for decreased corneal reflex (*vide infra*),[2] about 67% for facial paresis, and about 71% for the presence of hypertension. The minimal predictive value of a negative test was less than 40% for any of the signs in the table. Even the old historic pearl, "Don't diagnose cerebellar hemorrhage in a nonhypertensive patient," breaks down. The minimal predictive value of a negative test for hypertension was only 40% (Rosenberg and Kaufman, 1976).

A Note on Terminology. We have invented two new statistical terms, the *maximal* predictive value of a positive test and the *minimal* predictive value of a negative test. These are defined as the predictive value of tests calculated from a series in which there were control subjects free of the disease being studied, but where the control subjects were probably not present in the same proportion as in real life. With the prevalence of the diseased subjects inflated, the apparent predictive value of a positive test can be considered the maximal predictive value of a positive test because it would decrease if the subjects without the disease were entered into the study in proportion appropriate to their prevalence. Conversely, the predictive value of the negative test defined in the artificial test population is the minimal predictive value of a negative test.

Cranial Nerve V: Motor

A Method for the Beginner

1. Place your hands over both of the patient's temporalis muscles and instruct the patient, "Grind your teeth." Normally, you should feel both of the temporalis muscles contracting. (Try it on your partner.)
2. Next slip your hands down to the masseter muscles at the lower posterior angle of the mandible. Again, instruct the patient to perform bruxism (teeth grinding) or simply ask him to chew.

[2] The corneal reflex will be impaired in all conditions wherein the facial muscles are paralyzed.

TABLE **26.1** *Differential diagnosis of intracranial hemorrhages*

Finding	Cerebellar hemorrhage	Thalamic–subthalamic hemorrhage	Putaminal hemorrhage	Pontine hemorrhage	Ruptured aneurysm without intracerebral clot
Hemiplegia	No	Yes	Yes	Quadriplegia or bilateral motor signs	No
Size of pupils	Small, often	Small, often unequal	May be normal	Usually pinpoint	Variable
Pupillary reaction	Yes	Maybe	Yes	Maybe	Yes
Facial weakness	Ipsilateral peripheral mild	Contralateral central	Contralateral central	Contralateral, possibly	No
Sensory deficit	No	Yes	Yes	Yes	No
Conjugate gaze palsy	Common	Maybe	Yes	Yes	No
Side	Ipsilateral	Contralateral	Contralateral	Ipsilateral	—
Reversed by ice water?	No	Usually	Yes	No	—
Sixth nerve palsy	Yes	Yes	No	Yes	Maybe
Hemianopia	No	Yes, clears early	Maybe	Maybe	Maybe
Early inability to walk	Yes	No	No	Yes	No
Vomiting	Severe and repeated	Occasional	Occasional	Yes	Yes
Convulsion	No	No	Yes	No	Yes
Unconscious at presentation	Maybe	No	No	Yes	Often
Eyes deviate downward	No	Yes	No	No	No
Ocular bobbing	Yes	No	No	Yes	No
Preretinal hemorrhage	No	No	Occasional	No	Yes
Abrupt evolution	Often within hours	No	Occasional	No	Yes
Decerebrate posture	Bilateral, usually late	Unilateral	Unilateral	Unilateral	Late

From Brennan R, Bergland R. Acute cerebellar hemorrhage. *Neurology.* 1977;27:527–532; Fisher CM, Picard EH, Polak A, et al. Acute hypertensive cerebellar hemorrhage diagnosis and surgical treatment. *J New Ment Dis.* 1965;140:38–57; Plum F, Posner JB. *The Diagnosis of Stupor and Coma.* 3rd Ed. Philadelphia, PA: FA Davis Co; 1982; and Vincent F. Cerebellar hemorrhage. *Minn Med.* 1976;59:53–458, with permission.

Again you should feel both masseters contract under your hands. (Try it on your partner.)

3. The simplest test is to have the patient open his mouth against resistance. The jaw will deviate toward the less powerful side (M. Schlitt, *personal communication*, 1999).

A Rounding Ploy

The most common cause of reported bilateral temporalis muscle failure is the examination of an edentulous patient (not realized to be such) by a senior medical student on a neurology elective. (A senior medical student who is already specializing in neurology apparently no longer needs to examine the mouth. Because the cranial nerves do not show up on a computerized tomographic (CT) scan, there is nothing that can be missed by not looking inside the mouth.)

Rather, the edentulous patient should be instructed to gum his lips or lower jaw. (Skip the temporalis muscle examination and go directly to the masseter examination because without real teeth, even this maneuver will not generate as good a contraction of the temporalis as of the masseter.)

Additionally, when examining the mouth, perform the following maneuvers:

1. Rotate the tongue blade within the mouth to a vertical position.
2. Instruct the patient to grasp the tongue blade between his teeth.
3. Then ask him to wiggle the grasped tongue blade.

I prefer this to the usual method of having the patient simply grasp the horizontal tongue blade between his clamped teeth and "hold it in place." By requiring the patient to hold a vertical tongue blade and wiggle it, we also check the internal and external pterygoid muscles. The former method tests only the masseter and temporalis.

Do not check the pterygoids in a patient with a weak masseter because the jaw may dislocate (S. Horenstein, *personal communication*, 1988).

For the Advanced Resident. Landry–Guillain–Barré–Strohl[3] syndrome tends to spare the masseter muscle, which is frequently involved in myasthenia gravis. This distinction is empiric but not scientific because we have no underlying basis for explaining it (see Chapter 1).

Cranial Nerve V: Sensory

Skin Sensation

Because the detailed examination takes the same amount of time as the screening examination, one might as well do the detailed examination. The technique is called double simultaneous stimulation (DSS).

A Method

1. Ask the patient to close his eyes and report which side(s) is (are) touched.
2. Start at the top and work down, being careful to perform testing within each of the three divisions of the trigeminal nerve. Within each division, touch both sides at once as well as one side only.

If the patient insists on watching you, stand in front of him and have him stare at your nose. Moving both your index fingers constantly so as to eliminate visual cuing, occasionally bring one or both fingers close enough to the face to touch the skin lightly.

Do not tap the skin because this stimulates several different branches of the sensory system. You may find it easier to perform the same test with cotton wisps instead of your fingers.

Interpretation. If the afflicted side does not perceive touch with DSS, although it may perceive touch when stimulated by itself, there is generally a cortical lesion. With peripheral disease, the subject will not perceive either a single or double stimulus.

You may wonder why one is sure to touch one side only in each of the three divisions if DSS is superior to single stimulation. First, the subject may have peripheral disease. But even with cortical disease, the single stimulation in each division must be randomly performed so as to break up the "halo" effect. That is, if the subject with the cortical disease always sees the fingers wiggling, even when they are not touching him, and he is always touched doubly, he may learn to report the sensation of DSS each time even when he is not experiencing it, thus defeating the purpose of the test.

Despite the verbosity of the description, DSS with control single-sided stimulation of all three divisions of the trigeminal nerve can be performed in 8 seconds.

Corneal Reflex

The sensory nerve V also supplies the corneal surface.

A Method

1. Moisten a soft piece of cotton or other material that will not scratch the cornea. The corner of a tissue works fine. This should of course be clean. It should not have been used on another patient, especially one with Jakob–Creutzfeldt disease, acquired immune deficiency syndrome (AIDS), or herpetic keratitis.
2. Touch the cornea. This sounds simple, but one must steer between the Scylla of the sclera or the eyelid and the Charybdis of the visual startle reflex. Have the patient look up while you approach the eye from the side so that the patient cannot see the wisp of cotton. When the wisp is over a portion of the cornea not covering the pupillary aperture, go straight in, observing both eyes for the blink.
3. Repeat on the other side.

If you touch the cornea of the right eye and neither eye blinks, what is your diagnosis? If only the left eye blinks, what is your diagnosis? (Write your answers down before looking in Appendix 26.2.)

An Alternate Method

The French method, which avoids the potential for contagion as well as the problems listed in step 2, is to take a straw or a syringe and squirt air at the cornea (S. Horenstein, *personal communication*, 1988).

Interpretation. The corneal reflex involves two different cranial nerves, V for the afferent limb and VII for the efferent limb, and not knowing this can get you into a pickle. This should remind you of the advertisement for the 57 varieties of Heinz pickles. This pickle (5×7) can remind you of the afferent limb (V) and the efferent limb (VII). Accordingly, we can progress to the study of the seventh cranial nerve with relish.

Compromise of cranial nerve IX in a patient with rheumatoid arthritis, manifested by facial paresthesias or loss of the corneal reflex, is suggestive of brainstem compression from "cranial settling" (vertical subluxation of the odontoid process), owing to involvement of upper cervical vertebrae (Bouchaud-Chabot and Lioté, 2002).

Corneomandibular Reflex

If corneal stimulation also produces a lateral deviation of the mandible, it is called the *corneomandibular reflex*. This is probably an associated movement more than a true reflex. It indicates supranuclear interruption of the corticotrigeminal tract on the side of the stimulated cornea.

Whereas the corneomandibular reflex is abnormal in the awake patient, its presence in a comatose patient indicates that the brainstem is intact. It is one of the "brainstem release" signs rarely used today.

The Perioral Reflex

A Method

Place a finger in the angle of the mouth and strike it to see the reflex closure. (Alternately, stroke the nasolabial fold.)

Interpretation. This reflex tests cranial nerve V as the afferent and tests cranial nerve VII as the efferent. Except in infants, there is normally no response. In an adult, the infantile response of contraction of the nearby facial muscles is a cortical release sign, signifying severe damage.

Cranial Nerve VII: Somatomotor Portion

Routinely, we test only the somatomotor portion of cranial nerve VII that supplies the muscles of facial expression.

[3] Strohl was actually the medical student who found the patients and presented them at neurology conference (Guillain et al., 1916).

Peripheral versus Central Palsy

A Method

1. Observe the patient for greater than normal facial asymmetry, including the inspection of the lateral palpebral commissures. Also look for flattening of a nasolabial fold.
2. Ask the patient to raise his eyebrows and look for symmetric wrinkling of the forehead.
3. Ask the patient to close his eyes tightly. Try to force the lids open with your thumb, rolling the skin against the supraorbital rim, *not* against the globe, in order to detect weakness of one eyelid.
4. Ask the patient to show his teeth (or gums) and to puff out his cheeks.

Interpretation. Central facial palsies are caused by cortical (upper motor neuron) lesions, and peripheral palsies are caused by lesions of the facial nerve or its brainstem nucleus (lower motor neurons). Note that "peripheral" as used here includes a portion of the central nervous system, the nucleus in the brainstem.

The upper third of the face, including the muscles of the forehead and the orbicularis oculi, is supplied by a nucleus that receives fibers from both sides of the cerebrum. The lower part of the face is supplied by a nucleus that receives fibers from only one side of the cerebral cortex. Therefore, if the patient experiences a supranuclear lesion (e.g., a lesion of the motor cortex or of its fibers descending to the nucleus) that produces a facial palsy, the forehead will be spared. Such a patient would be able to perform step 2 normally but not step 4. On the other hand, if the facial palsy is due to a lesion of the peripheral nerve or of the brainstem nucleus, the forehead and eyelids will also be paretic. (See "The Bells of Scotland," below.)

In the case record, be sure to describe the findings (e.g., "upper face (not) spared"); "peripheral" and "central" palsy are conclusions, not findings.

When localization of a lesion based upon loss of the upper third of the facial muscle is not completely compatible with the rest of the examination, the former should be abandoned because about 5% of the population does *not* have crossed innervation of the motor supply to the upper third of the facial nerve. In such patients, total facial hemiparesis cannot be used as evidence of nuclear (brainstem) disease. Of course, if the upper third is preserved, that is still evidence of supranuclear disease.

Emotional versus Volitional Pathways

Some patients with facial palsy are wrongly suspected of malingering because they cannot seem to move the facial muscles on the examiner's command but are capable of moving them if the examiner can make the patient laugh involuntarily. This retention of motor function in response to strong emotion is called *volitional palsy*. In contrast, patients with *emotional* (or mimetic) *palsy* can move their facial muscles on command but not during the spontaneous expression of strong emotion. They may be misdiagnosed as parkinsonian or schizophrenic. It is for the latter reason that the instructions on judging affect require the examiner to measure more than just facial appearance.

In the former instance, the patient has a lesion in the corticobulbar pathway between the motor cortex and the pons. In the latter, the lesion is in a more anterior frontopontomedullary connection.

A person who can smile but not whistle might also be accused of malingering. But this is exactly what is seen as an early manifestation of progressive muscular dystrophy of the facioscapulohumeral type (Landouzy–Dejerine), in which the seventh cranial nerve is intact but the orbicularis oris is asymmetrically involved (Perkoff and Tyler, 1953).

Bell Palsy

Bell palsy, shown in Fig. 26-9, is a subset of the peripheral variety of facial palsies, referring to lesions distal to the geniculate ganglion (DeJong, 1979).

Hunt syndrome, which is herpes of the geniculate ganglion, produces a peripheral facial palsy and herpetic vesicles on the eardrum. This situation is the only one in which it is useful to know that the eardrum, parts of the ear canal, and parts of the tragus are supplied by the somatosensory branch of cranial nerve VII. The actual distribution varies from person to person.

A Method

The best test[4] for Bell palsy is to ask the patient to close each eye, individually, in turn. In very mild cases, the patient will not be able to close the eye on the afflicted side without also closing the contralateral (normal) eye.

Two Caveats. If you do not know the history, merely observing the patient's facial appearance, especially around the eyes, can be misleading. With recovery, partial contractures may set in on the paralyzed side, making it appear to be the more contracted side. Hence, the normal side may appear comparatively paretic.

Similarly, a third nerve lesion can produce upper lid ptosis (mimicking the contractures mentioned above), but not the lower lid droop seen in cranial nerve VII lesions.

During an eye blink, the lower lid normally moves 2 to 5 mm horizontally and nasally, thereby producing a partial vacuum in the lacrimal system that helps to clear it and to wipe the tears away from the globe. However, in facial palsy, the lateral motion is lost, and in fact the lower lid does not move up much at all. This is best demonstrated with a camera, but the effects can be seen without it (Arrigg and Miller, 1985). The tears build up on the affected side. Because they form a stagnant pool, they can permit bacterial overgrowth and infection.

The Bell Phenomenon

Ordinarily, when one attempts to close the eye against a resistance by contraction of the orbicularis muscle of the eyelids, the globe rotates upward. This is not pathologic but rather is a normal synkinesia (associated movement). Hence, we speak of the "Bell phenomenon," not the "Bell sign." Usually, it is not noticed because the closing eye obscures the globe.

A Method

Ask a naive medical student to try to keep his eyes closed while you try to open them by opposing them with your thumbs. Press extra hard on one side only to keep that eye from closing, and you will see the Bell phenomenon. On the other side, you must let the eyelid win over your thumb, or your subject may visually fix on a spot as he concentrates on his task. Such visual fixation can eliminate the Bell phenomenon bilaterally.

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[4] Because of the extremely large number of talented people who have worked in the field of neurology over the past century, we are blessed with a surfeit of neurologic tests for each lesion. Accordingly, we will often try to pick one simple test and ask the reader to consult DeJong for a fuller catalog.

FIGURE 26-9 This drawing of a Canadian (Ojibway) Indian mask called "Broken Nose" demonstrates the classic features of Bell palsy: loss of forehead wrinkling, deviation of the mouth to the nonparalyzed side, sagging of the paralyzed side with loss of the nasolabial crease, and the rounder eye suggesting lagophthalmos (failure of the upper eyelid to move down when the patient is asked to close his eye). (Drawing by William Snavely, with permission.)

Interpretation. The Bell phenomenon may be significant only when it is absent. (Such phenomena are often likened to Sherlock Holmes's barking dog.[5])

Bilateral absence occurs in (a) visual fixation by a neurologically intact person, (b) brainstem or lower motor neuron oculomotor disease, but not supranuclear oculomotor disease, (c) bilateral disease of the third cranial nerves (unlikely by Occam's razor), and (d) 15% of healthy persons (Adams and Victor, 1985).

The phenomenon is absent unilaterally in ipsilateral third cranial nerve disease (not seventh).

In Bell palsy, whenever the orbicularis muscle closes, it must do so against an effective "resistance." Because of this, it is particularly easy to observe the unmasked (normal) Bell phenomenon on the afflicted side (DeGowin, 1965; Delp and Manning, 1975). This has led to the unfortunate conclusion that the Bell phenomenon is a "sign" of Bell palsy. This convoluted reasoning is reinforced by the similarity in names and the unhappy practice of describing both palsy and phenomenon in the same physical diagnosis textbook passage. This emphasis on one situation in which the phenomenon is present has unfortunately detracted from its more salient use in those situations—outlined above—in which it is absent.

Because it is a normal synkinesia, the Bell phenomenon has been used by others to distinguish an oculomotor conversion reaction from "organic" pathology. (If the synkinesia occurs, the innervation of the eye muscles must be intact; therefore, the patient is "malingering" if unable to move his eyes on command.) However, there are problems with relying on this phenomenon alone because, if the phenomenon persists, the patient might actually have supranuclear disease.

The Bell phenomenon has also been confused in some texts with the Negro sign, the movement of the globe up and out when the patient looks up at the ceiling. The Negro sign is present in both central and peripheral facial palsies. The Negro sign, like the Bell phenomenon, is more pronounced on the side of the lesion.

Historic Note: The Bells of Scotland

Both Bell palsy and the Bell phenomenon were named for Sir Charles Bell (1774–1842). However, this was not the Bell whose clinical acumen so impressed the medical student Arthur Conan Doyle that he became the model for Sherlock Holmes (Doyle, 1958). The latter, Joseph Bell, was a scion of the other Scottish family of eminent surgeons, also named Bell.

---

[5] Just as Willie ("the Actor") Sutton never actually authored the words of Sutton's law (Chapter 27), so Holmes never referred to the dog as the "barking dog." In the adventure called *Silver Blaze*, Watson asks Holmes:

"Is there any point to which you would draw my attention?"

"To the curious incident of the dog in the night-time."

"The dog did nothing in the night-time."

"That is the curious incident." remarked Sherlock Holmes.

Later, Holmes explains, "...I had grasped the significance of the silence of the dog, for one true inference invariably suggests others. The Simpson incident had shown me that a dog was kept in the stables, and yet, though someone had been in and had fetched out a horse, he had not barked enough to arouse the two lads in the loft. Obviously the midnight visitor was someone whom the dog knew well."

Thus, this should be called the *silent dog*, not the barking dog (as Sutton's law should be named after William Dock, who actually described it).

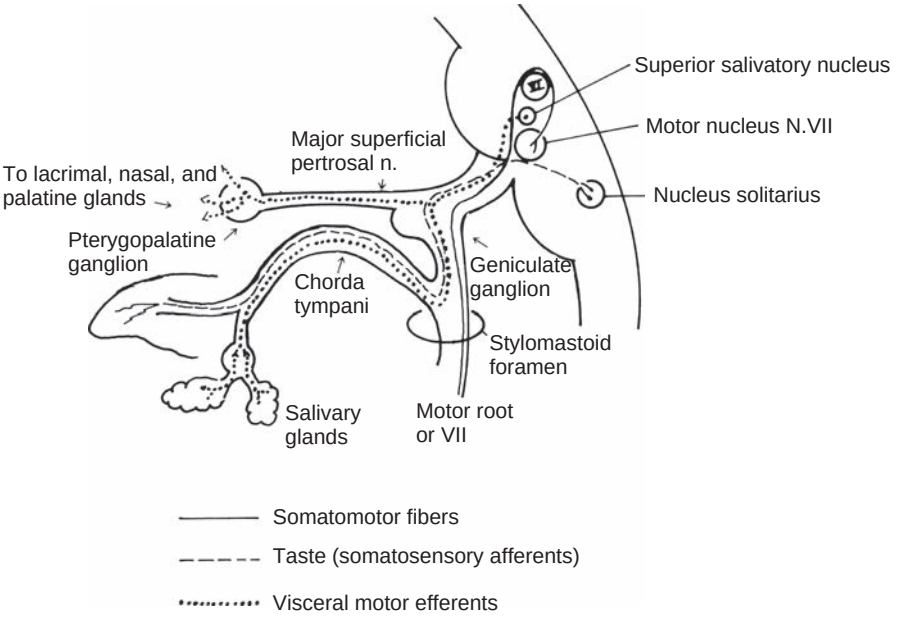


FIGURE **26-10** The branches of cranial nerve VII.

Unilateral Hyperacusis

Unilateral hyperacusis may be caused by a palsy of the stapedius muscle, which normally functions to dampen the oscillations of the ear ossicles. For detecting this finding, one may use the tape recorder and earpiece described for interviewing patients who are hard of hearing (see Chapter 2). The two sides may be compared by noting the volume setting that elicits the acoustic reflex (a startle, wince, grimace, or blink in response to a sound sufficiently loud to be unpleasant). Pure tones and white noise appear to be the best discriminators, not music (Johns, 1986).

Cranial Nerve VII: Visceral Sensory

Taste is more complicated than smell because the anterior two thirds of the tongue is innervated by cranial nerve VII, the back of the tongue by cranial nerve IX, and the epiglottal taste buds by cranial nerve X. It is difficult to detect unilateral lesions or lesions affecting individual cranial nerves VII, IX, or X because of diffusion of the test substance or overlap of innervation (L. Huntoon, *personal communication*, 1998). Testing with sugar solution is very difficult because it tends to roll across the midline. Some examiners use only salt on the side of the tongue (S. Horenstein, *personal communication*, 1988).

Tests of taste are of little use in the routine neurologic examination but are included for use in patients with relevant problems.

A Method

The following technique may be adapted for use in lieu of a formal taste sensation laboratory:

1. Make up 0.25% aqueous solutions of table salt, table sugar, quinine (about one-half tsp per liter) and about 1 tsp per cup of kitchen vinegar. These solutions should be strong enough for an older person (who will have fewer taste buds) to taste. Remember, you are not testing for threshold but for total absence of taste.[6]
2. Write on a piece of paper the words "sweet," "salty," "sour," "bitter," and "plain water." (If the patient is unable to indicate his choice by pointing to one of the words, you may have trouble with the test. (a) If the patient is allowed to open his mouth to speak his answer, the solutions will run from one side to the other and from front to back, so the loss of taste on one side or the other, or in the area supplied by a specific cranial nerve, may be missed; (b) If the patient is allowed simply to signal "yes," the vinegar may stimulate cranial nerve V in the mouth and nose, and this sensation may be reported as a "positive" response even though the patient is not experiencing taste.)
3. Have the patient protrude his tongue, and paint on the solutions one at a time, in one place at a time, and on only one side at a time. To test cranial nerve VII, use the salt and sugar solutions on the anterior tongue. To test cranial nerves VII and IX, paint the sour solution (the vinegar) on the lateral surface, anteriorly for VII, and posteriorly for IX. To test cranial nerve IX, paint the bitter quinine solution posteriorly but do not let the patient swallow. (He will not be able to as long as his tongue is sticking out.) The quinine solution should be used last.
4. With the tongue still out, ask the patient to make a response.
5. After each response, let the patient rinse with some water, which should be expectorated, not swallowed.

Interpretation

Unilateral impairment of taste on the anterior two thirds of the tongue signifies a lesion of cranial nerve VII, located above its exit from the stylomastoid foramen, either in the portion that passes through the auditory canal (the chorda tympani) or in the portion that proceeds to the geniculate ganglion. Contrariwise, supranuclear lesions are not accompanied by alteration in taste (Fig. 26-10).

Causes of bilateral decrease or loss of taste are listed in Table 26.2.

Complaints of dysgeusia (as in gold therapy) or hypogeusia may actually have normal taste tests but abnormal olfactory nerve testing. In fact, olfactory problems are the most common cause of dysgeusia, a problem that seems especially prominent in otherwise normal postmenopausal women (M. Schlitt, *personal communication*, 1999).

[6] The median detection threshold/median recognition threshold, in mmol per L, for healthy subjects, is as follows: sodium chloride 12/30; sucrose 12/30; hydrochloric acid 3/6; urea 120/150 (Henkin et al., 1971).

TABLE **26.2** *Causes of bilateral loss of taste or hypogeusia (decreased taste)*

Neurologic disease
Familial dysautonomia
Local afflictions
Facial hypoplasia
Sjögren syndrome
After radiation therapy
Laryngectomy
Drug therapy
Steroids
Diuretics
Aspirin
Nutritional deficiencies
Niacin deficiency
Zinc deficiency
Endocrine conditions
Cushing syndrome
Hypothyroidism
Diabetes mellitus (abnormal taste of glucose only)
Pseudohypoparathyroidism
Infectious diseases
Dengue fever
Influenzalike infections
Other systemic conditions
Sarcoidosis
Cancer
Chronic renal failure
Cirrhosis of the liver
Burns
Hypertension (abnormal taste of salt only)

From Clee MD, Burrow L, Delaney P, et al. Taste and smell in disease. *N Engl J Med.* 1983;309:1062–1063; Schiffman SS. Taste and smell in disease. *N Engl J Med.* 1983;308:1275–1279; and Wechsler IS. *Clinical Neurology.* 9th Ed. Philadelphia, PA: W. B. Saunders; 1963, with permission.

Cranial Nerve VII: Visceral Motor

The visceral motor branches of cranial nerve VII supply the salivary (Chapter 13) and lacrimal glands (see the Schirmer test, Chapter 10). Unilateral dryness of the eyes and mouth could result from a lesion of this nerve. If bilateral, the problem is probably end-organ damage as in Sjögren syndrome.

Cranial Nerve VIII

The auditory portion of cranial nerve VIII has already been tested with the Rinne, Weber, and Schwabach tests during the examination of the ear (see Chapter 11). And you will of course have already checked the ear for cerumen.

The simplest screening test, which has a fairly high sensitivity, is simply to rub one's fingers together or a few strands of hair between one's fingers, near the patient's ear, and compare the two sides (M. Schlitt, *personal communication*, 1999).

One aspect of the vestibular portion of cranial nerve VIII was tested during the examination of the extraocular movements, when the presence or absence of nystagmus was noted.

The findings from these two examinations might have been recorded under the respective regional examinations.

Additionally, screening tests for vestibular function, the Bárány test, and the caloric response are discussed later because the vestibular system is most easily tested as a system.

The Arbit Hearing Test

A device constructed of a stethoscope, a tuning fork (512 Hz), and a suction cup or feeding nipple (designed to attach the tuning fork to the stethoscope diaphragm) has been described for improved bedside testing of hearing (Arbit, 1977). One also needs a device such as a hemostat for clamping (occluding) the stethoscope tubing (Fig. 26-11).

A Method

1. Preinstruct the patient that he is to indicate when he is no longer able to hear the sound of the tuning fork.
2. Place the earpieces of the stethoscope in the patient's ears.
3. Strike the tuning fork, which is attached to the stethoscope diaphragm by the feeding nipple.
4. Place your ear close to the tuning fork and listen while watching the patient for the preestablished signal.

Hearing is said to be normal if the patient hears the sound at least 15 seconds longer than the examiner.

FIGURE **26-11** Set-up for Arbit test to check hearing in one ear at a time. The examiner needs to put her ear close to the tuning fork.

Comment. Although this test seems to work as well or better than the contemporary "customary" examination, it has not been compared with the Rinne and Weber tests.

A Unilateral Method. Test each ear individually by clamping the tubing leading to one ear. The patient again signals when he no longer hears the sound (in the ear served by the nonoccluded tubing). At that instant, unclamp the tubing and ask the patient if he now hears the sound. If he does, you have identified a definite hearing difference between the two ears.

Loudness Recruitment

The device described above can also be used to detect loudness recruitment by comparing the two ears at different tuning fork intensities (for details, *vide infra*).

If you could carry around an audiometer in your pocket and use it as an independent variable for testing your diagnosed patients with unilateral deafness, you would soon make an interesting discovery: Patients with unilateral sensorineural deafness due to the involvement of the hair cells of the organ of Corti would show very strange audiograms (Fig. 26-12).

The schematic audiogram demonstrating recruitment (*solid circles*) would not be seen in non–end-organ deafness (*squares*). Looking at the circles, we see that the infirm ear has a very high threshold. The difference between the good ear and the infirm ear decreases at higher decibels (louder sound). In fact, at very high amplitudes (sound intensities), the good ear and the bad ear hear equally well! The bad ear is thus said to have "recruited" something that permits it to be equal to the good ear at very suprathreshold intensities.

For the Attending. Recruitment is almost never found in sensorineural deafness due to involvement of the cochlear nerve (VIII) (i.e., its presence implies disease of the end organ rather than that of the communicating neural tissue). The exception has been the report of this phenomenon in a few cases of acoustic neurinoma (cerebellopontine angle tumor) (Alpers and Manchall, 1971). In a general medical practice, recruitment most often is a sign of Ménière disease.

A Bedside Test for Unilateral Recruitment

A Method

Hit the tuning fork very lightly, and rapidly present it to each ear in sequence. Repeat several times, each time with a lighter touch on the tuning fork, varying the ear that is stimulated first. The purpose is to search for evidence that threshold or near-threshold sound is significantly different between the two ears. This point is operationally defined as the softest touch on the tuning fork that will permit an ear to perceive the sound as softer (than the opposite ear) regardless of the sequence of presentation.

Next, hit the tuning fork as hard as you can and quickly present it to each ear. If the subject now reports that the infirm ear hears just as well as—or sometimes better than— the good ear, recruitment is said to be present (Chandler, 1958).

This test was developed by Chandler, who noticed that the patient who has recruitment will often give visual signals of discomfort when the maximally activated tuning fork is presented to the infirm ear.

Of course, the patient with nonrecruiting sensorineural deafness, or one with a conductive deafness, will continue to report that the sound is much louder in the "good" ear, no matter how hard you hit the fork.

Obviously, the Chandler test for recruitment can be modified as by Arbit in that the clamped and unclamped tubing permits the

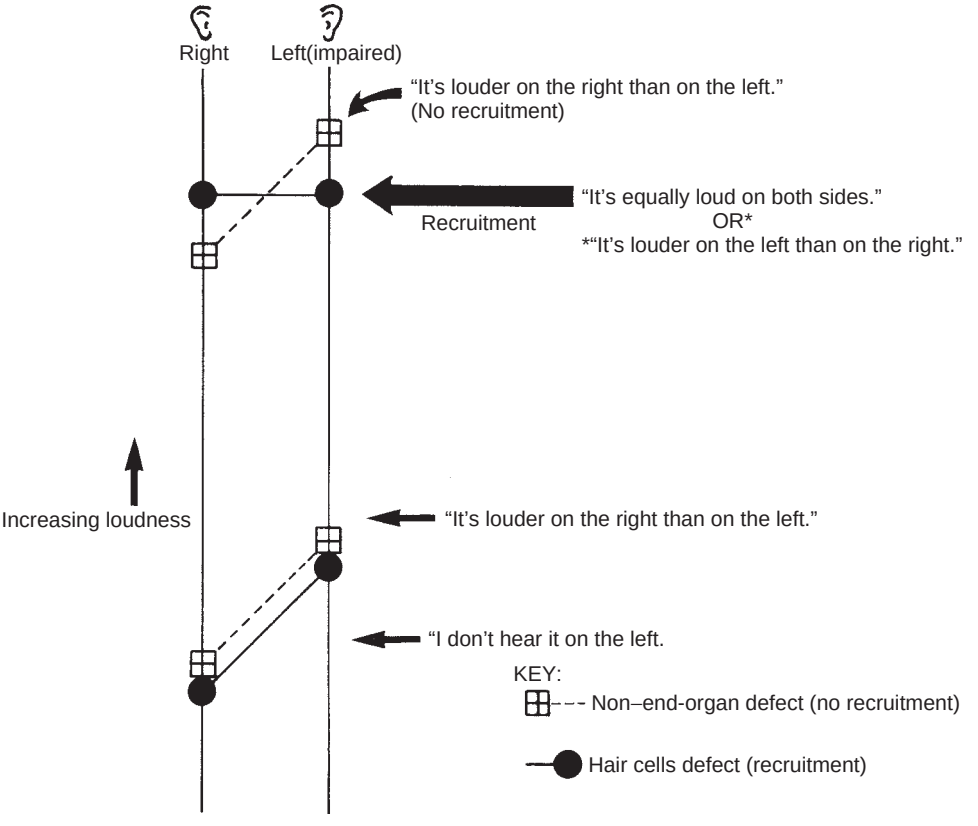

Right
Left(impaired)
"It's louder on the right than on the left."
(No recruitment)
"It's equally loud on both sides."
OR*
*"It's louder on the left than on the right."
Recruitment
Increasing loudness
"It's louder on the right than on the left."
"I don't hear it on the left.
KEY:
Non–end-organ defect (no recruitment)
Hair cells defect (recruitment)

FIGURE 26-12 Loudness recruitment thresholds (see text).

same tuning fork to be presented to each ear in sequence without actually moving the fork around the patient's head.

For the Guru. We need to acknowledge that the distinction between sensorineural and conduction deafness derives from 19th-century concepts. They were based upon tuning fork tests and therefore are still convenient. However, with increasing information about the cochlear portion of the ear, exceptions to the old concepts have arisen (Goodhill, 1979).

More on Ménière Disease

Taking the History

The classic tetrad of Ménière disease is fluctuating hearing loss, episodic vertigo typically lasting 1 to 5 hours, tinnitus, and aural fullness. The tinnitus is often described as a low-frequency roaring. The aural fullness may be triggered by high-salt meals or caffeine, although the patient may not have noticed the connection. Thus, a low-salt diet may be helpful. The classic tetrad does not always exist at initial presentation.

Ask the patient: "Does the vertigo start 'right out of the blue' when you are seated and doing nothing, or does it come on with sudden movement of your head or body?" With Ménière disease, the vertigo seems to occur unprovoked, whereas with benign paroxysmal positional vertigo (BPPV), it tends to be brought on by rolling over in bed, lifting dishes to the top shelf, turning to check traffic, or picking something up.

Also ask: "Is the spinning fast or slow?" Patients with Ménière disease or BPPV generally spin fast, whereas migraineurs and patients with anxiety spin slowly.

Low-Frequency Hearing Loss

Ménière disease should not be diagnosed without vestibular signs (*vide infra*) and low-frequency hearing loss. One way to detect the latter is to see whether the patient can hear the dial tone on the telephone. This test works all over the world, except in Vienna, where the dial tone is the 440–Hz A to which the Vienna Philharmonic tunes up (S. Horenstein, *personal communication*, 1988). Low-frequency tuning forks (such as 128 Hz) can be used to demonstrate this at the bedside.

Patients may describe *diplacusis*—a distortion of pitch or perception of pitch difference from side to side. Check for this by striking the tuning fork, presenting it to alternate sides, and asking whether the "pitch" (not volume or timbre) is the same in both ears. Some patients will not be able to understand this concept, but many perform the test very well. The pitch in the infirm ear will generally be described as "lower."

Syndrome of Acoustic Neuroma (Vestibular Schwannoma)

The first major neurologic abnormality is auditory, although the tumor arises from the vestibular branch of the cranial nerve VIII (Patten, 1996). Hearing loss is found in 98% of these patients, tinnitus in 70%, disequilibrium in 67%, and nystagmus in 26% (Harner and Laws, 1983).

On vestibular testing (see later in this chapter), more than 80% of patients will have at least some decrease on one side.

An eighth-nerve tumor, especially if bilateral, suggests the diagnosis of neurofibromatosis type 2 (Karnes, 1998).

Cranial nerves V and VII may also be involved: 26% to 29% of the patients have facial numbness, and 10% to 12% have facial weakness. Either dysgeusia or lingual numbness from involvement of chorda tympani fibers is found in 6%. An abnormal corneal reflex is found in 33%.

It is essential to check the corneal reflex because loss or depression of this reflex is the most consistent early sign. The fifth nerve is lifted up by the tumor and the afferent fibers for the corneal reflex seem especially sensitive to such distortion. Numbness over the face may appear later (Patten, 1996).

Only about 10% have diplopia, and abnormal eye movements are found in 11% (owing to involvement of cranial nerves III, IV, and VI).

Cranial nerves I, II, IX, X, XI, or XII are collectively and individually involved, but rarely. (Rarely means <1% of the time.) Abnormalities of these cranial nerves, especially in a discontinuous fashion (i.e., not in numeric sequence), should suggest an alternative diagnosis.

As with other retrocochlear diseases, there is a disproportionate impairment in speech discrimination, as opposed to pure-tone audiometry.

With present imaging techniques, especially gadolinium-enhanced magnetic resonance imaging (MRI) and temporal bone scans, acoustic neuroma is diagnosed so early that the classic picture is no longer seen, just as brain tumors no longer present with papilledema (S. Horenstein, *personal communication*, 1988).

The acoustic nerve tumor is the most common type to occur in the cerebellopontine angle. Other tumors and lesions involving this area include meningioma; glomus jugulare tumor; cholesteatoma; eccentric pontine glioma; neuromas of cranial nerve V, VII, or IX; chordoma; astrocytoma of cranial nerve VIII; arteriovenous malformation; aneurysm of the intrapetrous carotid artery; chondrosarcoma; nasopharyngeal carcinoma; and metastatic deposits of carcinoma or lymphoma. Early involvement of cranial nerve VII suggests one of the alternate types, being quite rare in acoustic neuroma (Patten, 1996).

A Superspecialist Uses Tuning Forks

Dr Michael J. A. Robb of Phoenix, Arizona, a neuro-otologist, writes that he uses tuning forks ranging in frequency from 128 to 4,096 Hz at the bedside. Hearing can be checked using the 256 to 512 Hz forks for the Weber, Rinne, and Schwabach tests (see Chapter 11), and air conduction thresholds over five octaves can be checked quickly with the 128 to 4,096 forks, provided that the examiner has normal hearing and is willing to practice. Dr Robb reports that he can predict the shape and degree of hearing loss over five octaves to within 15 dB using six different tuning forks. The tuning forks also provide clues to hyperacusis, misophonia, migraine-related phonophobia, and diplacusis (M.J.A. Robb, *personal communication*, 2004). Formal audiometric testing should also be obtained. If done during symptomatic and asymptomatic periods, this is especially helpful for demonstrating the fluctuating hearing loss that makes Ménière disease more likely.

Cranial Nerves IX and X

Where accessible to the physical diagnostician, cranial nerves IX and X overlap so much that they can be considered together.

A Method for the Beginner

Examine the palate to see whether the uvula is in the midline position. In asymptomatic patients, it usually is.

Also perform a gag reflex at the conclusion of the examination of the throat. Simply let your tongue depressor slide back toward the posterior third of the tongue. In all likelihood, you will have already produced many gag reflexes inadvertently by the time you are polished enough to produce one intentionally. Accordingly, by the time you do that, you will know what it looks like.

The Uvula in Pathologic Conditions

A great deal can be learned from the position of the uvula in pathologic conditions. In Fig. 26-13, each row refers to a pathologic condition, except for the top row, which illustrates the normal. Each column represents a condition of examination. The figures in the left-hand column are the palate and uvula as observed at rest. The second column is the result of following the command to say "ahh."

If the individual has palsy, the uvula will be deviated toward the good (healthy) side. Please note that the uvula may not exactly point to the good side (as shown in the figure) but rather may seem to be hanging straight down on the good side of the midline.

In some cases of partial palsy, the uvula will hang in the middle, but on induced phonation ("ahhh") will move toward the good side. Again, in actual practice the whole area moves. The uvula again does not really point at the good side as shown in the figure, which is intended as a mnemonic.

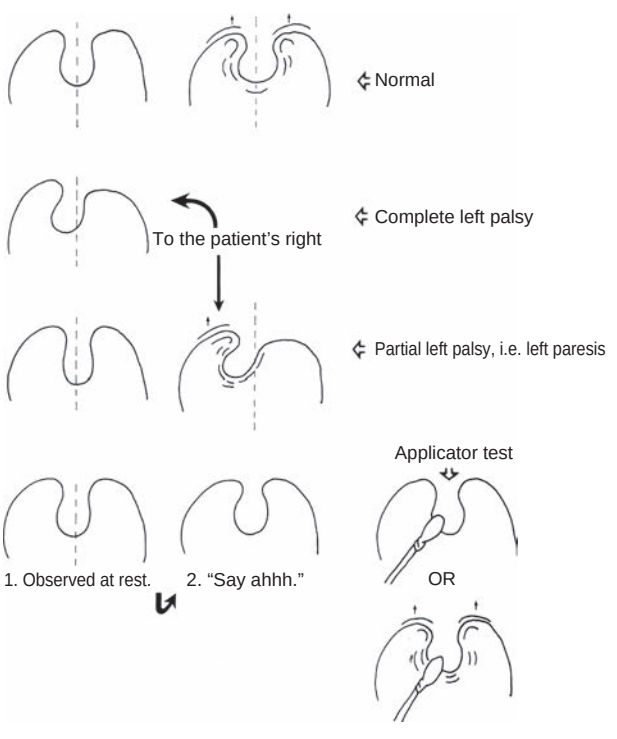


FIGURE **26-13** The uvula in various pathologic conditions. **Left column:** At rest. **Middle column:** On phonation ("ahhh"). **Right column:** Applicator test. **First row:** Normal. **Second row:** Complete left palsy. **Third row:** Partial left palsy (i.e., left paresis). **Fourth row:** Lower motor neuron disease of cranial nerves IX and X. **Fifth row:** Upper motor neuron disease of cranial nerves IX and X.

Sometimes the uvula is in the midline but does not move on phonation. Here we must be dealing with a bilateral paralysis. But does it result from upper or lower motor neuron disease? To find out, simply touch a cotton applicator to the uvula. If it does not move, one is obviously dealing with bilateral lower motor neuron palsy. If, as in the bottom panel, it does respond (bilaterally) to direct stimulation, one is dealing with bilateral upper motor neuron palsy.

Notice that we have not said whether IX, X, or both cranial nerves were involved in this palsy. This is because they usually go together. The most common causes seen in practice are involvement of the IX and X cranial nerves in brainstem disease. Sometimes, there is unilateral involvement due to the syndrome of the jugular foramen. In this instance, one also sees homolateral involvement of XI in addition to IX and X (syndrome of Vernet, *vide infra*).

Distinguishing Lesions of IX and X

If one wishes to separate lesions of IX and X, one is obliged to find a testable function served by one but not the other.

Although cranial nerve IX does supply taste to the posterior third of the tongue, it should be noted that cranial nerve X supplies the taste buds even further back. Given the vagaries of testing for taste in general, and without touching the anterior two thirds of the tongue in particular, the distinction can probably not be made on these grounds.

However, cranial nerve X does have some accessible and testable functions. Old-time neurologists used to perform the *oculocardiac reflex*. This was done by pressing on the eyeball and observing the slowing of the heart. If the visceral motor branches of X were interrupted, no such slowing would take place. (However, interruption of the afferent fibers of V also leads to loss of the reflex.) If one wishes to slow the heart rate without using drugs, this method may be safer than carotid massage (see Chapter 18). Demonstrating the absence of this reflex is required by some before declaring brain death.

Cranial nerve X also has somatosensory branches that supply the anterior aspect of the tragus, sometimes the posterior aspect of the tragus, sometimes a little spot of skin on the back of the ear, and sometimes the external auditory canal. Unfortunately, IX also supplies these areas in some persons. The best place to search for an anesthetic spot is on the tragus. If you find it, you have fair evidence of involvement of cranial nerve X.

Finally, X supplies somatomotor branches to the vocal cords.

Vocal Cord Paralysis

For the Attending. The following discussion presumes that you have performed indirect laryngoscopy or have consulted a laryngoscopist.

Total bilateral loss of cranial nerve X is usually associated with a fatal outcome, although the loss of X itself is not fatal, because both sides of the medulla oblongata must be damaged for a long distance in order to destroy the entire nucleus of X. A person can live with bilateral paralysis of the recurrent laryngeal branches of X, although he will have dyspnea and impaired phonation. If there is bilateral disease of the adductor branches, there will be impaired phonation but no respiratory difficulties. If there is bilateral paralysis of the abductor branches, there will be no difficulties with phonation

to speak of, but there will be severe dyspnea. The last is known as Gerhardt syndrome.

Unilateral laryngeal nerve palsies are a little more common. Unilateral recurrent laryngeal nerve palsy is associated with a raspy voice that easily fatigues. Its differential diagnosis is to some degree dependent on the laterality. If the left recurrent laryngeal nerve is affected, one should think of aortic aneurysm, trauma (e.g., thyroidectomy), mitral stenosis, or other causes of left pulmonary artery enlargement. If the right recurrent laryngeal nerve is involved, one should look for disease of the right pulmonary apex. Recurrent laryngeal nerve palsy of either side may be caused by pericarditis, goiter (Hamburger, 1986), tumors, and (rarely) tabes dorsalis. The most common cause of recurrent laryngeal nerve palsy is postsurgical, with operations on the anterior half of the neck, especially in the 20% of individuals who have an anomalous recurrent laryngeal nerve (M. Schlitt, *personal communication*, 1999). Unilateral superior laryngeal nerve palsy is usually the result of trauma.

Vocal cord immobility in patients with rheumatoid arthritis has been assumed to result from cricoarytenoid arthritis with joint fixation. Cervicomedullary compression (*vide infra)* should also be considered (Thompson et al., 1998).

Cranial Nerve X in Combination with Other Cranial Nerve Lesions

All of these are homolateral syndromes. When nerves IX, X, and XI are involved together, that is the syndrome of Vernet and indicates disease at the jugular foramen, if unilateral. The syndrome of Vernet plus involvement of cranial nerve XII is Collet–Sicard syndrome, due to the involvement of the posterior laterocondylar space with tumors of the parotid gland or carotid gland, tuberculous adenitis, lymphoma, or secondary tumors. The additional involvement of the sympathetics is known as the syndrome of Villaret and indicates that the lesion is in the retroparotid space, if unilateral. However, if only nerves X and XI are involved, that is the syndrome of Schmidt and should be attributed to disease of the central nervous system (rather than the peripheral nerves) until proved otherwise.

In a patient with rheumatoid arthritis, symptoms or signs related to cranial nerves IX-XII should trigger concerns about brainstem compression from "cranial settling" (*vide supra*). Sudden death can result (Menezes et al., 1985; Bouchaud-Chabot and Lioté, 2002).

Cranial Nerve XI

The trapezius muscles may be tested by having the patient shrug his shoulders. The sternomastoid muscles may be tested by having the patient rotate his head away from the side being tested (when facing you) against the resistance of the examiner's hand placed on the lateral aspect of the mandible opposite the side being tested (Fig. 26-14).

1. The supranuclear control of the spinal part of the nucleus of cranial nerve XI is unusual in that the hemisphere exerts control over the sternomastoid muscle on the same side and the trapezius on the opposite side. The functional importance is obvious: the right hemisphere activates the left limbs and also the sternomastoid that turns the head toward rather than away from the left. In patients experiencing a focal motor seizure, the head turns toward the convulsing limbs, as would be expected from this innervation pattern (Patten, 1996).

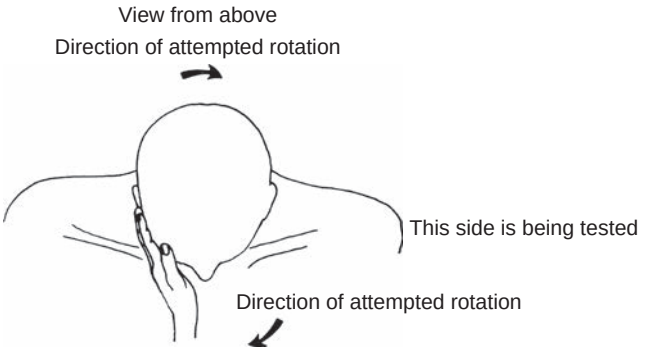


Figure 26-14 Testing the sternocleidomastoid. (See text.)

2. The function of the spinal accessory nerve may also be impaired by neck lesions that cause entrapment.
3. The most common cause of nerve XI palsies is surgical mishap in the posterior triangle of the neck (M. Schlitt, *personal communication*, 1999).
4. *Weakness of neck forward flexion is found in 100% of myopathies of any cause*. Do not test the side-to-side or rotational strength. Instead, tell the patient to put the chin on the chest and keep it there while you try to extend the neck (forcing the head up and back). The absence of sternomastoid weakness as demonstrated by this maneuver calls into question the diagnosis of myopathy (S. Horenstein, *personal communication*, 1988).

Cranial Nerve XII

A Method

Instruct the patient to stick his tongue out at you and then, as you lightly hold his mandible, ask him to point the tongue first to the right and then to the left.

In the *acute* stage of lower motor neuron (peripheral or nuclear) hypoglossal paralysis, the tongue points toward the paralyzed side; the paralyzed side may *appear* higher and more voluminous (the Dinkler sign, Fig. 26-15). This may also be seen in *acute* supranuclear hypoglossal palsies.

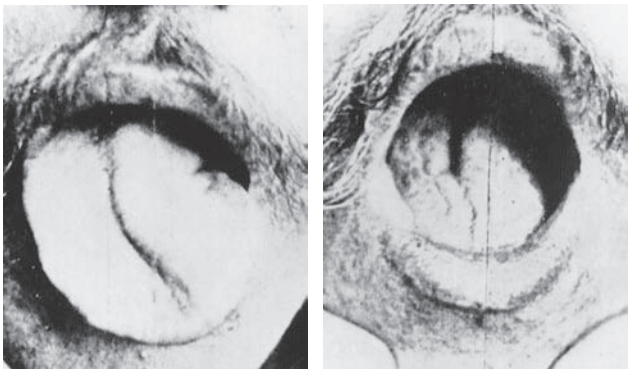
The Dinkler sign is not seen in acute malingering or acute conversion reactions.

A false-positive Dinkler sign may be seen in facial nerve palsy. The tongue appears to be pointing to the side of the facial nerve lesion on casual inspection, but closer examination will reveal that the tongue is pointing straight out but the patient is unable to open his mouth completely on the affected side.

The Dinkler sign associated with pain is now usually the result of carcinomatous involvement of the peripheral nerve XII. It may also be caused by basilar meningeal carcinomatosis, usually from breast cancer in women and prostate or lung cancer in men.

An uncomplicated *chronic* unilateral cranial nerve XII palsy will not usually "point to the bad side" when the patient first protrudes his tongue. The tongue will usually come straight out of the mouth, at which time you should inspect and palpate it for atrophy of the diseased side. (The bulging deformity of the Dinkler sign will not be seen if atrophy has supervened.)

But the patient with chronic hypoglossal nerve palsy (just like the patient with acute hypoglossal nerve palsy) will not be able to



A

B

FIGURE 26-15 **Top:** When a patient with the Dinkler sign sticks his tongue out, it points to the bad side. Also, the acutely paralyzed left side seems to be bunched up (the Dinkler sign), while the normal right side is relatively flat. When the patient puts his tongue back in his mouth, both sides are flat. Notice also that the tongue goes in on the right side—that is, it is pulled back to the good side by the good muscle. **Bottom:** This patient is faking an acute hypoglossal nerve palsy. Notice that his tongue is quite flat, in contrast to the photographs on top. (From Alexander L. The neurologic examination. *Pullen's Medical Diagnosis*. Philadelphia, PA: W. B. Saunders; 1950, with permission.)

move his protruded tongue to the normal side of his mouth. Be aware that if commanded to point the tongue to the good side, some such patients will move their mandible and facial muscles so as to bring the normal angle of the mouth over to the midline tongue. (If the tongue cannot come to the angle of the mouth, the mouth will come to the tongue. That is why you *lightly* hold the mandible.)

If there is ipsilateral basal occipital bone tenderness in the region of the hypoglossal canal (through which nerve XII exits the skull), one is most likely dealing with neoplasia (especially prostatic in the male), even if the patient has already survived long enough to have chronic hypoglossal nerve palsy with hemiatrophy.

The (relaxed) tongue can be examined for fasciculations at rest (*vide infra*) as well as for myotonia (see Chapter 13). These findings, of course, have no specific significance related to cranial nerve XII.

For tongue signs of chorea, see later in this chapter.

The Cranial Nerve Examination and Differential Diagnosis

The importance of the cranial nerve examination is shown by the fact that this portion of the examination occupies almost one fourth of an excellent textbook on neurologic differential diagnosis (Patten, 1996). Careful attention to the cranial nerves, especially in elderly patients with comorbid conditions, can help prevent dangerous misdiagnoses in this age of overreliance on sophisticated neuroimaging and aggressive therapy such as thrombolysis. For example, two elderly patients with myasthenia gravis were recently given an initial diagnosis of stroke by a neurologist, with CT findings considered to be confirmatory. History and findings of ptosis, dysarthria, difficulty in handling secretions, diplopia, tongue weakness, and neck flexor weakness eventually led to the correct diagnosis (Kleiner-Fisman and Kott, 1998).

The laterality of bulbar signs as compared with limb signs helps to localize the lesion to the brainstem (ipsilateral signs) or higher (contralateral signs).

Skilled Acts

Aphasia and Other Disorders of Speech

> How could we arrest scientific and industrial progress? By closing down, or by controlling, laboratories for research, by suppressing and controlling scientific periodicals and other means of discussion, by suppressing scientific congresses and other conferences, by suppressing universities and other schools, by suppressing books, the printing press, writing, and, in the end, speaking. All these things that indeed might be suppressed (or controlled) are social institutions. Language is a social institution without which scientific progress is unthinkable because without it there can be neither science nor a growing and progressive tradition (Popper, 1964, p. 154).

Aphasia is a word coined by Trousseau, meaning loss of speech. Technically, most patients categorized as aphasic have some speech and thus are actually dysphasic, but the question of the extent of the abnormality is much less important than two other questions: (a) Does the patient actually have an abnormality of speech itself (i.e., word selection and understanding) or of something else (e.g., the mechanism for articulation) that is revealed in the process of speaking? (b) For those patients who truly do have aphasia, what is the specific type?

What Aphasia Is Not

Aphasia is not mutism, although patients with global aphasia may be mute. Patients with mutism are unable to make sounds, but language function is retained, as may be demonstrated (in literate patients) by reading and writing, two functions that are almost always impaired in the true aphasic.

One method of testing is to show the mute patient the following message, printed in large block letters: "Put your left thumb on your right cheek." Some aphasic patients will not be able to follow this written instruction but all literate mute patients can. Some patients with mutism can hear and thus can follow spoken instructions or respond appropriately to yes-or-no questions and questions permitting small number responses to be given by holding

up fingers. Usually, if one understands the distinction between aphasia and mutism, the diagnosis of mutism will have been made long before reaching the formal neurologic examination.

Aphasia is also not dysarthria. Dysarthria is the inability to articulate clearly, typically because of brainstem or posterior fossa lesions. A dysarthric patient does get the approximate sounds in the correct order in the correct words in the correct arrangement. Likewise, aphasia is not a dysphonia, a difficulty in phonation due to cranial nerve palsies involving VII, IX, X, or XII, or an intrinsic disease of one of the end organs of sound-making such as the nasopharynx or tongue. If one remembers the distinction between dysarthria or dysphonia and aphasia, one will usually have made the diagnosis early in the interview. If there is a question, remember that language function is intact in dysarthria and dysphonia, so the patient will be able to respond to written instructions, make nonverbal responses, and write linguistically coherent material, as described above in mutism.

Good repeat-after-me test phrases for dysarthria or dysphonia (but not always for aphasia, *vide infra*) are, "Methodist Episcopalian," "around the rock the ragged rascal ran," and "Peter Piper picked a peck of pickled peppers."

Aphasia is also not cerebellar speech, which is a dysarthria.

Some apparent abnormalities of speech that are actually abnormalities of mental status may also be detected during the interview. These abnormalities could conceivably be confusing to the sophomore who did not know the correct definitions of these types of speech. *Word salad* refers to a verbal output characteristic of some (but not all) schizophrenic patients. It sounds jumbled up, like a salad, in the sense that a salad is a mixture of small amounts of many things with no predominant theme. Such patients are quite fluent, but the content of their speech makes no sense. Word salad can be aphasia; however, with the schizophrenic patient, it is the thought content that is abnormal, as reflected perfectly in the language that is produced. Fortunately for the sophomore, the schizophrenic patients who produce word salad usually do so in the context of so many other peculiar actions and mannerisms that the diagnosis is not long in doubt (see later in this chapter for diagnostic criteria).

Manic patients may also demonstrate their disease through language. *Pressure of speech* refers to an accelerated rate of speech and a relative inability to be quiet; it is therefore almost never confused with aphasia. *Flight of ideas* is just that. The main content of the speech is difficult to follow, not because of language problems but because the main subject of the monologue changes so rapidly. *Tangentiality and circumstantiality* (see Chapter 2, footnote 1) could also be confused with aphasia by the jejune. However, within the context of the other abnormalities of mania (*vide infra*), the distinction should be obvious.

Depressed patients may produce a small quantity of speech, slowly and sometimes softly, but the grammar, syntax, and word choice are all normal.

Caveats

The student must realize that the perfect correlation between anatomic localization and abnormality of function that is seen in other areas, say with valvular heart disease or spinal cord disease, does not always exist for aphasia. Most patients will not present with one of the "pure culture" clinical pictures about to be described. The clinical picture resulting from etiologies as diverse as metabolic encephalopathies or brain tumors or Alzheimer disease may vary from day to day in the same patient, even though the anatomic substrate is presumably unchanged. Nevertheless, there are still useful concepts and methods of examination. Anatomic correlation also improves with time spent with the patient and the sophistication of the examiner.

A Method

The examination for aphasia and other disorders of speech (broadly conceived) is carried out in two parts. The first consists of observations of the usual doctor–patient conversation. Look for fluency (the rate of speech) and the latency to beginning speech (S. Horenstein, *personal communication*, 1988). The second, which is used to classify aphasias, is based upon the patient's response to specific instructions. The specific abstractions from conversations and the specific maneuvers including test phrases are presented throughout this section *ad seriatim*.

The first part of the examination is not in itself sufficient to rule out aphasia; active testing is necessary.

Fluent versus Nonfluent Aphasias

Having determined that the patient does truly have aphasia, one next wishes to determine whether it is fluent or nonfluent. (Some characteristics of various aphasias are summarized in Table 26.3.)

1. The nonfluent (also referred to as Broca, motor, frontal, or expressive) aphasia is characterized by spontaneous speech that is slow, labored, increased in latency, often mumbled, and lacking grammatical niceties such as definite articles or appropriate suffixes. It resembles what one composed in the days of 10 words per telegram.

   The nonfluent aphasia signifies a lesion in the Broca area (Fig. 26-16).

   The patient with bilateral frontal lobe isolation described below may at first appear to have a nonfluent aphasia.
2. Fluent aphasias are characterized by speech of normal grammar and at least normal speed but inability to use the correct words. If asked what class of objects comprises a Ford, a Cadillac, and a Toyota, the patient may use an indefinite ("you know, the thing"), an operational definition ("what you come to work in"), a paraphasia ("a horse"), or a paranymy ("a bar"). (Paraphasia has a better prognosis than paranymy. For example, if someone means to say "my sister," but says "my niece," he is at least within the correct class of objects; whereas the paranymy "my blister" is not even close.)

   (a) *Conduction Aphasia*. To test for conduction aphasia, ask the patient to say, "No ifs, ands, or buts, please." Patients with conduction aphasia understand the directions to repeat the test phrase because their comprehension is intact. But their attempted repetition is impaired, and they will stumble over this particular test phrase. Oddly enough, some of those who cannot do this test phrase can easily repeat some of the longer, seemingly more difficult phrases that have been used. In fact, I have had patients with large cerebral metastases in the area marked C in Fig. 26-16 who could initiate and maintain long goal-oriented

TABLE **26.3** *Some common kinds of aphasia*

Aphasia type	Spontaneous speech	Comprehension	Repetition	Associated findings
Broca ("motor") aphasia	Nonfluent	Intact		Paresis of right face and arm
Conduction aphasia	Fluent	Intact	Impaired	
Isolation aphasia	Fluent	Impaired	Intact	
Wernicke ("receptive") aphasia	Fluent	Impaired	Impaired	Right superior quadrantanopsia
Nominal aphasia	Fluent	Intact	Intact	

From Geschwind N. Current concepts: Aphasia. *N Engl J Med.* 1971;284:654–656, with permission.

discussions (such as those concerned with obtaining cigarette privileges) without any evidence of error in their spontaneous speech but who could not repeat this phrase with any amount of practice.

(b) *Isolation Aphasia*. Patients with isolation aphasia are like parrots in that they can repeat any test phrase but do not understand what they are repeating. This ability may sometimes fool the examiner, but the aphasia can be detected by using a test phrase with a command in it, such as "put your left thumb on your right ear."

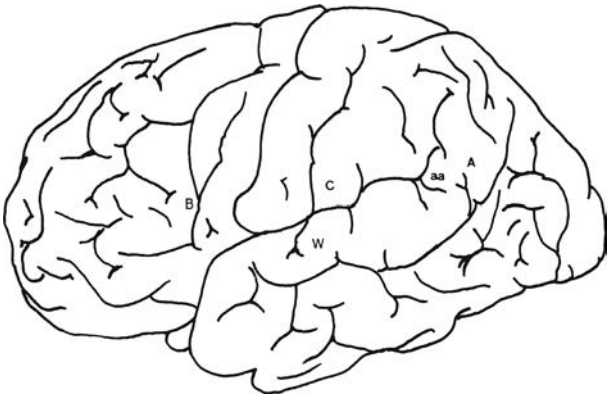


FIGURE 26-16 The speech areas. *B*, the Broca area, where lesions can produce a nonfluent aphasia. (Note the proximity to the motor area; you can see why afflictions of the Broca area are likely to be accompanied by hemiplegia.) *C*, the general area where lesions produce a conduction aphasia, a fluent aphasia in which the patient will attempt to follow the examiner's instructions, which he does understand. But he will not be able to repeat the test phrase, "No ifs, ands, or buts, please." Actually, conduction aphasia may occur with lesions in the C-shaped loop between B and W. *W*, the Wernicke area, where lesions may produce a fluent aphasia, in which the patient can neither understand nor respond to verbal repetition or other tasks. In the unhappy circumstance that both Wernicke and Broca areas are afflicted, the patient will have global (total) aphasia. *A*, the old "alexic" area where a lesion may leave competence in the spoken language but incompetence in selecting specific words or in writing, or Gerstmann syndrome. Region *aa* is one area associated with what was formerly called *amnestic aphasia*, or anomic aphasia in the old classification. Regions *A* and *aa* may overlap.

These patients have lesions that surround but do not involve either the Broca area or the Wernicke area. Isolation aphasia is very rare.

(c) *Wernicke (Receptive, Sensory, or Temporal) Aphasia*. Patients with Wernicke aphasia are unable to comprehend the instructions and are also unable to repeat the instructions. Thus, they fail to produce any test sentence on command.

Additionally, if given verbal instructions and asked to nod yes or no as to whether they understand the instructions, patients with impaired comprehension (as well as those with isolation aphasia) do *not* nod affirmatively. They just stare at the examiner. It is easy to see why this was formerly called *receptive aphasia* or "word deafness," although such patients are not deaf. (This can be demonstrated by continuing to speak as you walk in a circle around the patient and observe his head movements.)

(Another way of testing for comprehension is to give verbal instructions or instructions printed on a piece of paper—for example, "Tear this piece of paper in four parts; given me one, put one on the table, and keep two for yourself, one in each hand." Such instructions require no use of speech in the response. If the patient cannot comprehend, he will not be able to follow the written instructions.)

These patients have lesions in the classic Wernicke area as shown in Fig. 26-16.

(d) *Nominal Aphasia*. This type of aphasia is most often missed because the patient has intact comprehension and repetition and so passes all the tests above. But, like all aphasic patients, the patient with nominal aphasia has trouble naming objects. Sometimes, a rather long list of objects must be presented. Some neurologists use objects of increasing rarity, such as a wristwatch, the strap, the buckle, and, finally, the part of the buckle that fits into the leather hole. Hardly anyone knows the name of the latter (the tongue of the buckle). Thus, it permits testing for neologism: "Make up a word to describe this." (Aphasic patients cannot make up words.) "Pin" would be a good neologism. "Din" would be paranymy.

These patients may have lesions located at the angular gyrus or the adjacent portion of the temporal lobe or sometimes at

other places (Fig. 26-16). Sometimes there is no focal lesion but rather a metabolic encephalopathy. Occasionally, this type of aphasia occurs during recovery from one of the other types of aphasia. Additionally, naming problems are seen in the dementia of Alzheimer disease, in Huntington disease, and, to a lesser extent, in Parkinson disease (Frank et al., 1996).

You can see why the classification of aphasias has occupied the best minds of neurology for a long time, with a perfect solution not yet in sight.

Cerebral Dominance

Much has been made about determining handedness in the aphasic patient who has suffered a stroke because more than 99% of right-handed persons have their language function in the left cerebral cortex (Baker and Joynt, 1986; DeJong, 1979). It is said that about 50% of practicing lefthanders also have their language function in the left cortex, and a small percentage of these sinistrals may even have bilateral representation. It is also said that essentially all human beings are left-hemisphere dominant or perhaps codominant (M. Schlitt, *personal communication*, 1999). In any case, the value of determining handedness, if the patient cannot tell, may be purely academic.

There is some evidence that with nonalphabetic languages like Chinese, language function may reside in the right cortex of a right-handed person, although if such persons learn English or another alphabetic language, the language function for the alphabetic language resides in the left cortex of a right-handed person. To show the severe limitation of all the "rules," we have the situation of the Japanese language, which includes both alphabetic and morphogrammatic letters (the latter called *kanji*). These letters are learned in school at the same time and are used together in many kinds of printed matter. Yet, when a 32-year-old dextral Japanese woman suffered a proved hemorrhage of the left posterior inferior temporal gyrus, she lost her ability to read the kanji but retained her ability to read the alphabetic letters and words (Kawamura et al., 1987).

Agnosias

The agnosias are disorders in which the patient cannot recognize common objects nor tell their meaning.

Usually, only astereognosis is specifically tested for. (Stereognosis is the power of judging the form of an object by touch.) Common objects are placed in the patient's hand without allowing him to see them and he is asked to identify them. Examples include pens, keys, and coins. It is not necessary for the patient to be able to tell the exact denomination of the coin.

Apraxias

Apraxia is the inability to perform a task despite intact functional areas, and by tradition it refers to nonverbal tasks—for example, getting dressed.

There are two kinds of apraxia: ideational or ideomotor (due to posterior hemispheric lesions) and kinetic (due to frontal lesions). To distinguish them, take out a wooden matchbox and ask the patient to strike a light. Patients with ideational apraxia will not be able to slide the box open. (They cannot dial a telephone either.) They may rip it open to get to the matches inside. Patients with kinetic apraxia will go to strike the match but will hold it wrong so that it does not light or so that it breaks (S. Horenstein, *personal communication*, 1988). A patient with ideomotor apraxia may be able to perform a task spontaneously in certain contexts even though unable to do it on command.

A progressive deterioration of cognitive function, resulting in aphasia, agnosia, and apraxia, is seen in Alzheimer disease in the absence of prominent motor signs (Geldmacher and Whitehouse, 1997).

For further descriptions of agnosia and apraxia, see the section on "Parietal Lobe Syndromes."

Meningitis

Stiff Neck

A stiff neck that is resistant to passive motion may be the first physical sign of meningitis.

This sign, however, can also be present in rheumatoid arthritis, cervical osteoarthritis, polymyalgia rheumatica, and a wide variety of other cervical afflictions of the bones, joints, ligaments, and muscles of the cervical area. Thus, if the neck is supple, one can (usually) be reassured of the absence of meningitis—*except in the elderly, who may present with confusion and develop nuchal rigidity only when moribund*. But if the neck is stiff, the problem has still not been localized to the meninges. These days, the term "meningismus" may be used in neurology to signify a stiff neck from any cause.

Do not check for meningitis by flexing the neck in an unconscious patient unless head and neck trauma has been excluded. Additionally, be aware that meningismus can be a sign of a posterior fossa mass lesion, and flexion of the neck could provoke a foramen magnum herniation (M. Schlitt, *personal communication*, 1999).

The Kernig–Lasègue and Brudzinski Signs

History

Lasègue wrote a classic article on sciatica in 1864 without mentioning limitation of straight-leg raising. It is apparent that the authors of leading textbooks of neurology, which cited this article as the source of the Lasègue sign, had never read it (Wartenberg, 1956). The Kernig–Lasègue sign was first described in 1880 by a Yugoslav physician, Lazarevic (Clain, 1973). He has never received credit for it. His sign is known by two other names to two different groups of specialists who use it for different purposes. (Having encouraged the student to describe something original in the hope of eponymous immortality, it must now be recalled how many times the original innovator's name is lost to posterity. As Shaw noted, virtue is its own punishment.)

The next year, 1881, the sign was published by Forst, in French, in his MD dissertation. Forst credited his teacher Lasègue with having taught him the sign (Wartenberg, 1950).

In 1882, Kernig published the same test in a Russian journal, and he did it again in German in 1884. Up until this point, it is not clear that any of the authors knew of each other's work or that they realized they were all describing essentially the same sign.

In 1909, Brudzinski, a Polish physician, described his "neck phenomenon" sign in French, and then he did it 2 years later in German.

Methods of Eliciting the Nerve Stretch Signs

The Kernig version had many forms. Sometimes the legs were passively lifted from the bed in an extended position until there was resistance and flexion at the knee. Sometimes they were lifted with the knees in a flexed position until maximal hip flexion was obtained, at which point the knees were extended to check for resistance. And sometimes just one leg was manipulated. Kernig himself usually performed the maneuver with the patient sitting, as described in his own words (Verghese and Gallemore, 1987):

> In most cases of meningitis, contractures are not present in the extremities while the patient is lying down, whereas if one tries to extend the knee while the patient remains sitting, one succeeds only to an angle of about 135 degrees; in cases in which the phenomenon is pronounced, a right angle is maintained. The phenomenon is so striking that the difference between the entire absence of this contracture in the reclining position and its presence in the sitting position is so readily seen that it is worthwhile to pay particular attention to this symptom and to look for it in every case.

The Lasègue version has been described in Chapter 25.

In the Brudzinski ("nape-of-the-neck") sign, the legs were not manipulated. Rather, the meninges and nerves were stretched by flexing the neck, while the examiner looked for a flexion response in the lower extremities.

All of these nerve stretch signs are essentially the same (Wartenberg, 1950).

Semeiopathophysiology

With vigorous flexion of the neck, the spinal cord moves upward about 1 cm in the lumbar region, and the medulla oblongata may elevate as much as 4 mm. In fact, all maneuvers that put a stretch upon the nervous tissue and its coverings can elicit a limited number of responses. The pain (which will be in the correct distribution of one of the nerve roots) causes resistance to further movement, as in the "tight hamstrings" of the Kernig–Lasègue sign. The stretch can also be mechanically relieved by flexion at the hips and knees. Conversely, when the knee is extended (or flexed), the sciatic nerve root moves down (or up) tightening (or relaxing) in turn the stretch on the spinal cord.

In meningitis, the stiff neck is a problem of *forward flexion only*, because that is the motion that puts strain on the meninges. Resistance to lateral flexion, rotation, or extension must be explained by some other etiology.

Significance

The sensitivity of Kernig's version was 87% in the hands of Kernig (Kernig, 1907) and 57% in the hands of Brudzinski (Verghese and Gallemore, 1987), who found his own version to be 96% sensitive. More recent series are in the same range, although one can no longer be certain that the authors personally examined the patients.

False Negatives

With localized inflammation of the meninges, as with the localized meningitis that follows bacterial contamination of a neurosurgical wound, the stretch signs will be negative because almost all of the meninges that are stretched are not inflamed. Cryptococcal meningitis is an especially common cause of false negatives.

False Positives

False positives include the musculoskeletal conditions named in Chapter 25, spinal cord tumor, myelitis, tetanus, cauda equina tumor, "high sciatica," radiculitis, cerebrospinal syphilis, cervical cord trauma, MS, poliomyelitis, spina bifida (Wartenberg, 1950), sphenoid sinusitis, and other diseases of the spinal cord and its nerve roots, such as carcinomatous meningitis, sarcoid meningitis, and Mollaret meningitis. Subarachnoid hemorrhage causes meningismus, probably secondary to chemical meningitis. The most common false positive is a posterior fossa tumor (M. Schlitt, *personal communication*, 1999). Thus, the stretch signs are not as diagnostic for infectious meningitis as many seem to think.

Pediatric Cranial Bruits

It is stated that cranial bruits may be heard in 82% of children less than age 5 with purulent meningitis, lasting only 1 to 4 days after the initiation of therapy. Such bruits are not heard in adults with meningitis and they are heard in only 16% of children without fever and in only 18% of children with fever but without meningitis (Mace et al., 1968).

Posture

Rigidity

Disease processes that effectively cause transection of the brain at a mesencephalic level remove cerebral control over the rest of the body. This results in *decerebrate rigidity*, which is characterized by full extension of four limbs.

Lesions at a higher level produce *decorticate rigidity*, which is characterized by flexion of the upper limbs and extension of the lower limbs. If the head is passively rotated to face one side, the arm (as well as the leg) on that side will be extended, but the upper and lower limb on the other side will be flexed. If the head is then rotated to face the opposite direction, the formerly flexed side will now extend and vice versa. If the head is brought back to face straight forward again, the original position is resumed.

Asterixis

Asterixis[7] is the inability to sustain posture. It is commonly sought in the upper extremities especially as a diagnostic for impending hepatic encephalopathy. It consists of an intermittent, relatively nonrhythmic loss of posture, followed by a regaining of posture.

A Caveat for the Sophomore

Asterixis is sometimes referred to as the "liver flap." This is a bad term for several reasons. First, there are many etiologies other than hepatic disease. Second, "flap" implies that the phenomenon occurs

[7] Asterixis was a made-up word composed in a Greek bar (the Taverna) across from Boston City Hospital. Foley, a well-known wit, used it in a paper, never expecting it to be taken seriously (S. Horenstein, *personal communication*, 1988).

only in the hands. Although the hands are most frequently examined for this finding, asterixis also may be shown by the fingers, eyelids, tongue, toes, or, for that matter, any part of the voluntary musculature that is required to maintain posture. Finally, the word "flap" implies something rhythmic.

A Method

1. Have the subject extend his raised arms at the elbows and wrists, with the fingers extended and spread. Ask him simply to maintain this posture. Do *not* consider any *rhythmic* shaking of the fingers to be asterixis; such movements are tremors.
2. Concentrate on lapses in posture, which is quickly regained, then lost again. These may be rapid, like a tremor, but will be *intermittent and nonrhythmic*. Or, there may be a slow flapping of the hands that may seem to be rhythmic but only for a few beats. This can appear like the motion of a child episodically waving an irregular "bye-bye."

Other Methods

Dr Gert Muelheims of Missouri became frustrated with trying to teach encephalopathic patients to keep their hands maximally extended at the wrist for the purpose of demonstrating asterixis, and so he uses a sign described by Dr Carlos Alberto Leite of Miami. He requests the patient to squeeze the doctor's hand or the doctor's extended fingers. Patients who are unable to maintain a posture are unable to maintain a steady squeeze. The characteristic movements, rapid and arrhythmic, occurring in bursts, can be seen as well as felt (Leite, 1966).

Dr J. Posner of New York has the patient squeeze a semi-inflated blood pressure cuff with instructions to maintain the reading. The readings bounce around dramatically in patients with asterixis.

Significance

Although asterixis was discovered in 1949 by Foley and Adams in patients with hepatic encephalopathy, it quickly became obvious that other abnormalities could produce the same lesion. Perhaps the current importance of asterixis is not the length of the differential diagnosis it suggests, but rather its implication that, whatever the diagnosis, the condition is at a serious point. For instance, in one study of alcoholic liver disease, asterixis was the *only* admitting physical finding that had a statistically significant predictive value for mortality, the rate being 56% in those with asterixis, as opposed to 26% in those without it (Hardison and Lee, 1966).

A list of etiologies, no doubt incomplete, is given in Table 26.4.

TABLE **26.4** *Causes of asterixis*

Liver disease
Laënnec or other severe cirrhosis
Drug-induced or other deterioration of prior liver disease
Pulmonary failure
Usually owing to CO_2 retention, but sometimes to hypoxia (Kilburn, 1965) or bronchogenic carcinoma with bronchial obstruction
Renal failure
Other metabolic encephalopathies[a]
Hypokalemia
Hypomagnesemia
Bromide intoxication
Phenytoin intoxication (DeJong, 1979)
Glutethimide intoxication
Chloral hydrate intoxication
Intravenous ammonium chloride
Gastrointestinal disease
Whipple disease
Malabsorption syndrome
Idiopathic steatorrhea
Toxic megacolon of ulcerative colitis
Miscellaneous
Congestive heart failure
Leukemia with sepsis
Focal brain lesions (Degos et al., 1979)

[a]After Conn HO. Asterixis in non-hepatic disorders. *Am J Med.* 1960;29: 647–661, with permission.

Gait

If there is any portion of the physical examination even more difficult to teach didactically than the general appearance, it must be gait. The best way to learn it is to have a more experienced person point out to you the various abnormalities in actual patients. Accordingly, what follows is mostly in the nature of attempting to alert you to the kinds of abnormal gaits that you might see. Because gait is also dependent upon normal bones, joints, and all portions of the nervous system, there will inevitably be some cross-references between this section and others.

Spontaneous Manifestations

The spontaneous manifestations of a gait abnormality consist of what can be seen and heard as the patient attempts to ambulate normally. There are many apocryphal stories of diagnosticians whose consulting rooms were at the end of a long hall so that, watching the patient walk down the hall from the waiting room, the clinician might be able to make the diagnosis even before shaking hands with the patient. This is how they did it.

Inspection

1. Patients with painful skin lesions on the bottom of the feet or with hyperesthesia (increased sensitivity) due to neurologic disease or dysesthesia (unpleasant, painful sensations) walk with a peculiar light-footed step, carefully putting the foot down and quickly lifting it. They seem to be walking on a bed of hot coals.
2. Patients with girdle muscular dystrophy, hip dislocation, or weakness of the glutei walk with a waddle like a duck because of extensor overpull. (Some of these patients also have increased lordosis but this is usually not possible to see from the front as they walk toward you.)
3. Patients with ankylosing spondylitis have a normal pace, although their stooped position might at first suggest Parkinson disease.

They tend to take small steps and to keep their head forward and their hands in front of their body.

4. The hallmark of the parkinsonian gait is that the patient takes very small steps. This is called the *marche à petit pas (pas* as in *pas de deux)*, roughly translatable as "walk of little steps." However, *marche à petit pas* by itself can also be seen in cerebral and spinal conditions. The full demonstration of the specifically parkinsonian gait involves the addition of slowness and the absence of normally associated movements, such as swinging the arms as one walks. Furthermore, the parkinsonian may exhibit difficulty in getting started (first step retardation), festination (a speeding up of the rate of movement after walking is begun), and propulsion (the tendency to fall forward as if the body's center of gravity was always just a little bit ahead of the patient). Finally, the "peacock phenomenon" may be demonstrated as the patient is about to change directions or speed. As the hip reaches its maximum flexion (as part of the normal gait), it suddenly hitches up like a peacock step. This is actually a dystonia superimposed upon normal flexion. It is best seen with the patient walking around the room nude, although many patients of either sex do not wish to do this (S. Horenstein, *personal communication*, 1988).
5. Patients with spastic paraparesis take short steps, but in contrast to the parkinsonian gait, the toes never seem to leave the floor. Additionally, the knees cross in front of each other as the patient walks, and it is this latter peculiarity that has christened this the "scissors gait."
6. The circumduction gait is similar to the scissors gait and it is seen in spastic hemiparesis. The affected foot seems to be dragged through a convex semicircle as it steps forward in turn because of the inability to flex the hip. If the hall is long enough, the patient will eventually turn toward the wall on the side of the afflicted leg.
7. The "steppage" gait is characterized by a foot drop so that with each step the foot is lifted very high as if the subject were going up steps, but the toe of the lifted foot points down toward the ground in midstep. The foot seems to be walking through invisible tar or bubble gum. This gait is caused by any muscular or neurologic disease that afflicts the tibialis anterior and the long extensors of the toes.
8. The gait may be very *wide-based* in posterior column disease and other afflictions of light touch and proprioception. The patient with such sensory ataxia may also slap his feet down so as to get increased input from the sensory endings in the feet. These patients have more difficulty walking with their eyes closed in contrast to patients with the wide-based gait of cerebellar disease.
9. Weakness causes "pseudosensory ataxia" and possibly the inability to walk at all. This occurs in any patient who has been bed-bound for a long time or who has become weakened for other reasons. Such patients ask for help even before they stand up because they think they are going to fall (and they are often right). They are sometimes erroneously labeled as having a conversion reaction but their facial expression is not that of *la belle indifference* (the beautiful lack of concern), but of true apprehension (also see number 10, which follows).
10. Patients with cerebellar disease lurch from the knees, looking exactly like someone who is intoxicated with alcohol and is about to fall to the knees (hence the folk description of "knee-crawling drunk"). The gait is also likened to atrial fibrillation in that it is an irregular irregularity of rate, range (how far each step is), and direction (S. Horenstein, *personal communication*, 1988). Sometimes such patients are labeled as malingerers if their doctor does not make accurate observations or does not complete his neurologic examination.

    The cerebellar gait is also wide pedestaled, so inspect the intermalleolar distance of patients as they walk. Also ask them to stand with the feet as close together "as is comfortable" so that they do not fall. The distance between the internal malleoli should normally be 4 cm or less (S. Horenstein, *personal communication*, 1988).
11. The malingerer feigning a gait disorder actually lurches from the hips, not the knees. Additionally, the malingerer may intermittently be so uncooperative as to exhibit astasia-abasia ("can't stand, can't move"). The latter is also seen in pseudosensory ataxia, but the manner of falling in the two entities is different. The patient with gait 9 or 10 will go down all at once, and thus will fall in a sprawl, as if the ankles had been knocked out from under him. The malingerer will instead exhibit a biphasic fall: first, some prefall upper-extremity movement from a very stable hips-down pedestal, and then a moment later a "fall" or a crumple in a relatively narrow space on the floor. Such a patient will not sprawl widely, if at all, until the upper torso and arms are quite near the floor. As a rule, he will not hurt himself, although patients with gaits described in 9 and 10 often will. Accordingly, all these patients should be tested by a strong examiner who stands with his arms surrounding but not touching the patient, so as to catch the patient in case of loss of balance.
12. A very bizarre gait may be seen in Huntington chorea (*vide infra*), although technically it is not truly a gait abnormality because it is often *not* the same on every step. It is dance-like, unpatterned, and unpredictable. The chorea ("dance") movement disorder may sometimes be complicated by the patient's trying to minimize it or cover it or make it "more natural" by adding purposeful movements on top of the abnormality. Because the latter are truly and obviously volitional and because the total effect is quite bizarre, these patients are also sometimes misunderstood as uncooperative or malingering.
13. Patients who walk with their toes turned out simply have fallen arches. This is of little systemic significance outside of countries that have unusual health requirements for military conscription.
14. A mildly demented but severely incontinent patient with a marked wide-based apractic gait should be evaluated for chronic ("normal pressure") hydrocephalus. This is especially important in an elderly patient with a history of meningitis, head trauma, or a neurosurgical procedure in the previous several months. These findings suggest the presence of a communicating hydrocephalus, particularly when the apraxia of gait and incontinence are disproportionate to the dementia.

This is thought to be caused by selective enlargement of the third ventricle and stretching of the fibers coursing past it (M. Faria, *personal communication*, 1998).

Auscultation

At one time, it was possible to make diagnoses by listening to the patient walk down the hall while he was still around the corner and out of sight. Recently, I have not often been with house staff in such quiet places, but will give the tricks of the erstwhile trade for the fans of Sherlock Holmes.

Patients who slap their feet when they walk either have fallen arches or sensory ataxia. Some patients with sensory ataxia, but none of those with fallen arches, may actually slap with two beats on each step, first putting their weight on the heel and then striking the forefoot separately in an apparent attempt to increase sensory input. You can study this yourself after your foot "falls asleep." Notice the first steps you take with the afflicted foot before "the circulation comes back." (Actually, it is not the circulation, but the nerve transmission.)

A scraping sound alternating with a normal step will sound like a syncopated "slide-thump, slide-thump." This is heard in spastic hemiparesis as well as in unilateral musculoskeletal conditions.

"Slide-slide," without the syncopation, is heard in bilateral musculoskeletal disease, spastic paraparesis, or Parkinson disease.

A soft plopping step is heard in the stoppage gait.

Induced Abnormalities of Gait

1. Have the patient walk once with his eyes open and then again with his eyes closed. If the patient does noticeably worse with the eyes closed, it is a strong clue to a sensory ataxia. If the patient does equally poorly with eyes open or closed, the problem could be in the cerebral motor cortex (motor ataxia) or in the vestibular system or cerebellum.
2. Have the patient walk a straight line in tandem—that is, heel to toe. This exacerbates all gait problems, especially vestibular ones, and is often used for distinguishing the subtypes of cerebellar disease. Patients with lesions of the vermis will have truncal ataxia, and thus will fall toward either side, in random distribution. But patients with disease of a cerebellar hemisphere will tend to fall preferentially to the side of the lesion. Be sure to stay close enough to the patient to catch one who falls. This is a better test than the Romberg (*vide infra*) for distinguishing between cerebellar and vestibular dysfunction unless the latter problem is acute. Because it is performed with the eyes open, the visual cues can compensate for vestibular or proprioceptive problems.
3. Have the patient walk eight steps forward and eight back (the "compass test"). It is best to remove all visual clues: Walk with the patient and say, "Keep your eyes closed; I won't let you bump into anything" (S. Horenstein, *personal communication*, 1988). Those with vestibular or cerebellar disease will stray away from the original path, moving toward the side of the lesion. (With cerebellar disease, the turning may occur only on walking backward.) Eventually, the patient will touch all points of the compass.
4. Have the patient start from a sitting position in a chair. Patients with limb girdle dystrophy and patients with Parkinson disease have great trouble getting started, as may some patients with motor ataxia.
5. Ask the patient to walk on his heels. This cannot be done in motor ataxia or with spastic paraparesis or foot drop (steppage gait).
6. Ask the patient to walk on tiptoe. This cannot be done by patients with sensory ataxia, pseudosensory ataxia, cerebellar disease, spastic hemiparesis, or paresis of the soleus or gastrocnemius muscles.

Movement Disorders

Tremors

Rate

One can make a diagnosis with 90% certainty simply by *watching* the tremor (Jankovic and Fahn, 1980).

If the tremor is slow (3 to 5 Hz),[8] it is either a cerebellar tremor, which becomes worse with intention, or a parkinsonian tremor, which is worse (i.e., of greater amplitude) at rest. (This last point may be confusing to some in that the parkinsonian tremor may speed up with intention and this increase in rate is sometimes wrongly described as a "worsening.")

If the tremor is rapid (6 to 12 Hz), it is either primary, chemical, or, if observed with intention, parkinsonian.

State

Try to find a situation in which there is no tremor. If the tremor is persistent only at rest, this almost guarantees the diagnosis of Parkinson disease. There are actors, surgeons, mechanics, and skilled manual workers who show severe parkinsonian tremor at rest, but not a trace of it when they concentrate on their work or move into action (Sacks, 1990). Yet, the parkinsonian tremor disappears during sleep (Klawans, 1988).

Then try to determine what brings on the tremor. If it appears with the initiation or cessation of a movement (an "action" or "intention" tremor), it is probably cerebellar or other "movement-related" tremor. The cerebellar tremor is especially pronounced at the end of an action. The most extreme form of terminal intention tremor is the "bat's wing" tremor of Wilson disease (Patten, 1996).

If the tremor appears when holding a posture (e.g., holding the limb out against gravity), it is probably essential, senile, chemical—(e.g., coffee), or catecholamine-induced.

The most striking and diagnostic feature of benign essential tremor is said to be dramatic relief with alcohol (Patten, 1996).

Things are not always as simple as indicated in the last paragraphs. However, there are other clues (e.g., see the "pill-rolling tremor").

Etiology

The various etiologies of tremor are summarized in Table 26.5.

[8] One hertz = 1 cycle per second. A cycle is one to-and-fro movement.

TABLE **26.5** *Etiologic classification of tremors*

Cerebellar
Cerebellar degenerations and atrophies
Multiple sclerosis
Wilson disease
Drugs, toxins: phenytoin, barbiturates, lithium, alcohol, mercury, 5-fluorouracil
Hereditary sensory neuropathy (Dejerine–Sottas)
Midbrain ("rubral") tremor
Miscellaneous cerebellar lesions

Parkinsonian tremor
Idiopathic
Other: postencephalitic, basal ganglia toxicity (carbon monoxide, manganese, carbon disulfide), striatal toxicity (reserpine, phenothiazines, "designer drugs," etc.), tumor, trauma, vascular, chronic, hepatocerebral degeneration, striatonigral degeneration, olivopontocerebellar atrophy, progressive supranuclear palsy, Shy–Drager disease, Wilson disease, Huntington chorea, normal pressure hydrocephalus

Chemical and metabolic
Thyrotoxicosis, hypoglycemia, pheochromocytoma, epinephrine, isoproterenol, caffeine, theophylline and other catecholamine-like agents, L-dopa, amphetamines, lithium, tricyclic antidepressants, butyrophenones, thyroid hormone, adrenocorticosteroids, alcohol withdrawal, mercury, lead, arsenic, bismuth, carbon monoxide, methyl bromide, monosodium glutamate, sodium valproate

Primary
Autosomal dominant
Senile
Sporadic
With peripheral neuropathy: Charcot–Marie–Tooth disease
With other movement disorders: torsion dystonia, spasmodic torticollis

From Jankovic J, Fahn S. Physiologic and pathologic tremors: Diagnosis, mechanism and management. *Ann Intern Med.* 1980;93:460–465, with permission.

Chorea

Chorea means dance, and the term is quite descriptive of this disorder of coordinated movement. As a rule, chorea begins in just one limb and may be interpreted as fidgeting. Later, there may be involuntary facial grimaces, and finally the chorea spreads to the whole body. The chorea may become so violent that the patient throws himself off the bed (*folie musculaire*) in a manner that appears to be the volitional act of an insane person.

Chorea is aggravated by strong emotion. This is worth keeping in mind because of the current tendency to be suspicious of (a) the patient who is worse with strong emotion and (b) a diagnosis that cannot be made by the laboratory. Chorea is a clinical diagnosis; there is no laboratory or imaging procedure.

Chorea may be superimposed upon athetosis.

Types of Chorea

1. Sydenham chorea (St Vitus dance) occurs in acute rheumatic fever. Nowadays, it may be more common in systemic lupus erythematosus (Greenhouse, 1966) but is still very rare. It is a state (i.e., a self-limited condition) not a trait (Huntington, 1872):

> The disease commonly begins by slight twitchings in the muscles of the face, which gradually increase in violence and variety. The eyelids are kept winking, the brows are corrugated and then elevated, the nose is screwed first to the one side and then to the other, and the mouth is drawn in various directions, giving the patient the most ludicrous appearance imaginable.
>
> If the patient attempts to protrude the tongue, it is accomplished with a great deal of difficulty and uncertainty. The hands are kept rolling—first the palms upward and then the backs. The shoulders are shrugged and the feet and legs kept in perpetual motion; the toes are turned in and then everted; one foot is thrown across the other and then suddenly withdrawn, and, in short, every conceivable attitude and expression is assumed; so varied and irregular are the motions gone through with, that a complete description of them would be impossible.

2. Huntington chorea is a trait, not a state (i.e., it does not get better). It comes on gradually, often taking years to develop fully, "until the hapless sufferer is but a quivering wreck of his former self" (Huntington, 1872). It may begin in any decade; those cases inherited from the paternal side tend to have an earlier onset (S. Horenstein, *personal communication*, 1988). It is inherited as an autosomal dominant condition. There are three major symptoms: involuntary movements, changes in behavior and personality, and cognitive impairment. The involuntary movements are quick and nonstereotypic. They are much more coarse and move the joints through a much greater amplitude than seen with any tremor but are much less severe and more controlled in appearance than the flailing arm movements of ballismus.

   The first description of Huntington chorea was actually given by Elliotson (1832), not Huntington:

> When it [chorea] occurs in adults, it is frequently connected with paralysis or idiotism, and will perhaps never be cured. It is very rare for you to remove the affection if it occurs in an adult, or if it occurs in a local form. It will sometimes take place in one arm only, or in the head, or some of the muscles of the face, so that the person makes faces continually. In cases of this description I have never seen the affection cured. It then appears to arise for the most part from something in the original constitution of the body, for I have often seen it hereditary.

   Huntington disease has been shown to be caused by an expanded $(CAG)_n$ repeat on gene IT15 (or huntingtin) on chromosome 4. Gene-negative cases with all the clinical features, including apparent autosomal dominant transmission, have been described (Rosenblatt et al., 1998).

   The presence or absence of subtle involuntary movements is not a reliable sign concerning the existence of incipient Huntington disease. Assessment of video recordings by experienced neurologists gave both false positives and false negatives (de Boo et al., 1998).

3. Choreiform movements may be seen with L-dopa toxicity in parkinsonian patients or in association with chronic administration of neuroleptics (see discussion of tardive dyskinesia). In the latter instance, the abnormal movements involve only the buccal, lingual, and mandibular musculature, although trunk and limbs may become involved in severe cases.

A Method

1. A simple trick for diagnosing chorea is to ask the patient to stick his tongue out and keep it there.
2. The patient with manifest chorea cannot maintain the tongue in a protruded position. (The patient with advanced Parkinson disease or Wilson disease cannot keep the tongue *in* the mouth.)

Lesions Causing Chorea

Typically, the lesion of chorea is degenerative changes in the contralateral basal ganglia (for hemichorea), particularly the caudate nucleus and putamen, associated with degeneration of the striatonigral gamma-aminobutyric acid (GABA)–ergic pathway neurons.

Athetosis

Athetosis[9] literally means "without posture" or "not capable of being fixed in a position." It differs from chorea in that it is much more writhing in nature. Also, the athetoid movements are more confined to the head, neck, and distal extremities, especially the upper extremities. Athetoid movements are slower but larger in amplitude (excursion) than normal movements. They differ from asterixis by being continuous between two extremes (e.g., between flexion and extension, or perhaps between internal and external rotation). They frequently contain a pause in what is called the "habitual attitude." When athetosis ends in dystonia, the habitual attitude is the position in which the patient "gets stuck."

Sometimes it is difficult to decide whether the patient has chorea or athetosis. In such cases, the patient is said to have "choreoathetosis" by analogy with "fib-flutter."

Pseudoathetosis is seen in diseases of sensory input such as tabes dorsalis. The patient seems to be making wide, deliberate, slow excursions of the limbs for the purpose of increasing sensory input. Pseudoathetosis of the hands has been called "the piano-playing tremor."

Athetosis typically occurs in a setting of hypoxia and ischemia of the cerebral cortex and basal ganglia, as in cerebral palsy, cerebral anoxia, or stroke (especially in children). It can also occur in Wilson disease.

[9] The word "athetosis" was invented by Dr Hammond, who was remarkable for writing the first North American neurology textbook, for being the only neurologist who ever became Surgeon General of the United States, and finally for being the only Surgeon General of the United States to be court-martialed (S. Horenstein, *personal communication*, 1988). He was forced to resign, but later was completely exonerated and restored to the rank of Brigadier General by President Rutherford B. Hayes. While he was Medical Director of the Army of the Potomac, he developed the first ambulance unit, field supply unit, and field hospitals, with the aid of Dr Jonathan Letterman and General George B. McClellan. These reforms made a dramatic difference in the treatment of the wounded, who were previously left on the battlefield for days without medical attention. However, Dr Hammond incurred the enmity of Secretary of War Edwin Stanton, who deliberately suppressed his projects (M. Faria, 1994).

Hemiballismus

Hemiballismus may be initially confused with chorea but it is characterized not so much by a dancing motion as by a throwing out of one side of the body in an uncontrolled, episodic, and sometimes violent manner. The patient resembles a hemiparetic playing the net in a volleyball game, hence the Greek name *hemi* (a lateral half of the body) plus *ballismus* (jumping or throwing). With hemiballismus there is typically a vascular lesion of the subthalamic nucleus (the nucleus of Luys contralateral to the movement). Also unlike the movement disorders mentioned above, the primary movement occurs at the shoulder (rather than the hand). Physiologically, it is a rebound of the arm (above the head) from a decerebrate posture. Thus, it is actually the limb that is "thrown."

Tics

Tics are repetitive brief contractions of a muscle or group of muscles. They may be hard to distinguish from habit spasms, which can be voluntarily suppressed. The most dramatic tic syndrome is that of Gilles de la Tourette, generally manifested by snorting, grimacing, grunting, and explosive involuntary vocalizations of obscenities (coprolalia). Obsessive–compulsive disorder may accompany Tourette syndrome or be an alternate expression of the genetic predisposition. Tourette syndrome may accompany attention deficit or hyperactivity disorder (*vide infra*).

Tics have reportedly occurred in association with numerous congenital and acquired neurologic and neuropsychiatric syndromes and with a number of drugs. Movements labeled as tics might actually represent another disorder such as chorea or myoclonus (Kumar and Lang, 1997).

Dystonia

In dystonia, the distortions of movement result from abnormal tonus in certain muscle groups. Usually, the sustained contraction produces a twisting and repetitive motion that can result in a sustained posture. Sometimes the dystonia is a minor complication of a neurologic disease *sui generis*. Thus, the extraocular muscles of the globe are actually experiencing dystonia in oculogyric crises of postencephalitic Parkinson disease (*vide infra*). But in other diseases, the dystonia is the main clinical feature of the disease (e.g., Brueghel syndrome—isolated blepharospasm and oromandibular dystonia) (see Fig. 9-7).

A characteristic feature of dystonia is the sensory trick or *geste antagonistique*, whereby patients can temporarily suppress the hyperkinesia by touching the affected area or adjacent body parts. This is of both diagnostic and therapeutic value. A very slight stimulus may suffice to overcome a strong mechanical effect; occasionally, a mere elevation of the arm without actually touching the head may produce the effect. Voluntary movement in the direction opposite to the dystonia may be aided when performed against resistance. Such a gesture is called a *counterpressure phenomenon* (*Gegendruckphänomen*) (Krack et al., 1998). Such effects have led some to the (erroneous) conclusion that the dystonia is "psychogenic."

There are many types of dystonia, which may be either generalized or focal. The most common type of focal dystonia seen at a movement disorders clinic is cervical dystonia, commonly called *spasmodic torticollis*—a misnomer, at least in many cases, because

patients usually display a combination of abnormal postures (Cardoso and Jankovic, 1997). The sustained posture of the head and neck involves lateral deviation and rotation. The patient may complain of stiffness and spasm in the neck muscles before the postural abnormality is apparent. The muscles of the neck, including the sternocleidomastoid, trapezius, levator scapulae, and posterior cervical muscles, may become visibly hypertrophied.

Torticollis is a dramatic presentation in patients who have been treated with high-dose phenothiazines or butyrophenones, or acutely in the abuse of certain drugs, such as ecstasy (Priori et al., 1995). It can also occur in L-dopa-treated Parkinson disease (Poewe, 1987) or as the first manifestation of Huntington disease, in one case preceding other manifestations by 10 years (Ashizawa and Jankovic, 1996).

In a tertiary pediatric orthopedics clinic, 18% of 288 children with torticollis had a nonmuscular etiology: Of these, 30% had Klippel–Feil anomalies, and 51% had a neurologic condition such as an ocular disorder, brachial plexus palsy, or tumor or congenital malformation of the brain (Ballock and Song, 1996). Torticollis can be the sole initial sign in juvenile rheumatoid arthritis, signifying atlantoaxial subluxation (Uziel et al., 1998). Acute torticollis was the presenting sign of a case of spontaneous pneumomediastinum (Dekel et al., 1996). In children, local infective causes, mainly in the upper respiratory tract, are common causes of torticollis (Uziel et al., 1998).

Head tilt has been described as a classic sign of a posterior fossa tumor, though diagnosis has often been delayed. One mechanism might be pressure on cranial nerve XI from herniated cerebellar tonsils (Gupta et al., 1996). Other neurologic signs and symptoms should be sought assiduously. Other possibilities include tumor, disc, or dislocation in the cervical spine (Turgut et al., 1995; Casey et al., 1995). Compression of cranial nerve XI by a dilated vertebral artery due to hypoplasia of the left internal carotid (Kikuchi et al., 1995) was found in a 32-year-old woman with a 10-year history of right head tilt with hypertrophied left sternomastoid.

Parkinsonism

Disease of the basal ganglia–striatal dopaminergic system can take many forms. The archetype of these is Parkinson disease[10] once called *paralysis agitans* (shaking palsy). (This is a misnomer as there is no paralysis, which is a loss of motor function as opposed to a paresis or weakness.) In most cases, the cause is unknown. There are a number of causes of secondary or acquired parkinsonism. Cases of parkinsonism following viral encephalitis are increasingly rare, and carbon monoxide poisoning always was a rare cause. Currently, many cases seem to be pharmacogenic (Table 26.5). Other causes include head trauma, cerebrovascular disease, and hydrocephalus.

Signs

Gait and Tremor

The characteristic gait and tremor have already been discussed. An additional aspect of the parkinsonian tremor is the so-called "pill-rolling" movement of the fingers, in which the thumb moves in opposition to the four fingers, especially the first two. Because pharmacists no longer roll pills, perhaps the term should be changed to the "stem-winding" movement of a watch owner. As such watches become rare, perhaps we should change to a "jeweler's screwdriver" movement.

Cogwheel Rigidity

The best test of the extrapyramidal system (now generally understood to be inclusive of the basal ganglia, the striatum, the substantia nigra, and the descending connections) in terms of diagnosticity is *cogwheel rigidity*. It was once almost pathognomonic of Parkinson disease; but as both L-dopa and phenothiazines became widely prescribed, drug-induced parkinsonism became a more common cause. However, the latter has recently become less common because of awareness of this side effect and the development of better drugs.

A Method

1. With the patient relaxed, passively extend the upper extremity at the elbow over a period of about 4 seconds. Then flex the elbow back to the original position over about 3 seconds. Repeat a few times.
2. If the patient has cogwheeling, you will feel alternate periods of resistance and relaxation, occurring about three or four times per 90 degrees of flexion or extension.
3. The sensation is as if you were pulling against a very soft ratchet or cogwheel, each spoke representing an area of resistance, regularly placed. The spaces between the spokes of resistance are the areas of normal easy passive movement. Once you have elicited the finding, it is unforgettable.

An Alternate Method. Dr Simon Horenstein of Missouri does not flex at the elbow but rather rotates the arm at the radioulnar joint.

Other Signs

Patients with Parkinson disease have difficulty performing two tasks simultaneously, as may be demonstrated by asking the patient to "tap the top of your head and stick your tongue out at me" (after you have determined that each task can be performed separately). Although this will exacerbate many movement disorders, it was specifically used in the pre-L-dopa era as a way of bringing out the movement disorder of Parkinson disease.

Another useful test, which is based upon the paucity of associated movements in parkinsonism, is the *Souques leg sign*. This may be demonstrated by suddenly thrusting the seated patient backward in his chair. Normally, the legs would kick out as a synkinesia but in parkinsonism there is no such movement.

As Parkinson disease advances, the facial expression becomes sparse.

Other features are a tendency to protrude the tongue (just like in Wilson disease), increased salivation, a monotonous tone to the speech, a general stiffness and poverty of all movements (i.e., rigidity with bradykinesia), and micrographia (small handwriting). The latter can best be seen by collecting signatures (sometimes from medicolegal release forms) made over a long period of time.

The glabella tap reflex is elicited by percussing the forehead with your index finger, taking care to have your finger outside the

[10] Parkinson disease was first described by renowned English surgeon James Parkinson in 1817, 5 years after he described appendicitis and its fatal complication of perforation.

patient's range of vision. A positive response is the blinking of both eyes, which usually fatigues after 5 to 10 blinks (Rao et al., 2003).

The akinesia or bradykinesia of parkinsonism is not purely motor. There may also be a corresponding "stickiness" or bradyphrenia of thoughts.

One of the remarkable paradoxes of parkinsonism, at least of the postencephalitic type, is that some patients who usually exist in a virtually frozen state can by certain stimuli be instantaneously triggered into a supernormal frenzy of amazingly agile activity (Sacks, 1990).

The most eloquent description of the disease and its progression is that of Parkinson himself (Parkinson, 1817), who defined the disease as

> … involuntary tremulous motion, with lessened muscle power, in parts not in action and even when supported; with a propensity to bend the trunk forwards, and to pass from a walking to a running pace: the senses and intellects being uninjured….
>
> The first symptoms perceived are, a slight sense of weakness [not paralysis], with a proneness to trembling in some particular part: sometimes in the head but most commonly in one of the hands and arms [especially the nondominant hand, i.e., the left in most persons]. The symptoms gradually increase in the part first affected: and at an uncertain period, but seldom in less than twelve months or more, the morbid influence is felt in some other part…. After a few more months the patient is found to be less strict than usual in preserving an upright posture: this being most observable whilst walking, but sometimes whilst sitting or standing. Sometime after the appearance of this symptom, and during its slow increase, one of the legs is discovered slightly to tremble, and is also found to suffer fatigue sooner than the leg of the other side: and in a few months this limb becomes agitated by similar tremblings, and suffers a similar loss of power.
>
> Hitherto the patient will have experienced but little inconvenience; and befriended by the strong influence of habitual endurance, would perhaps seldom think of his being the subject of disease, except when reminded of it by the unsteadiness of his hand, whilst writing or employing himself in any nicer kind of manipulation. But as the disease proceeds, similar employments are accomplished with considerable difficulty, the hand failing to answer with exactness to the dictates of the will. Walking becomes a task which cannot be performed without considerable attention. The legs are not raised to that height, or with that promptitude which the will directs, so that the utmost care is necessary to prevent frequent falls….
>
> The propensity to lean forward becomes invincible, and the patient is thereby forced to step on the toes and the fore part of the feet, whilst the upper part of the body is thrown so far forward as to render it difficult to avoid falling on the face. In some cases, when this state of the malady is attained, the patient can no longer exercise himself by walking in his usual manner, but is thrown on the toes and forepart of the feet; being, at the same time, irresistibly impelled to take much quicker and shorter steps, and thereby to adopt unwillingly a running pace. In some cases it is found necessary entirely to substitute running for walking; since otherwise the patient, on proceeding only a very few paces, would inevitably fall, … as first noticed by Gaubius, who says, "I have seen one who was able to run, but not to walk."
>
> His words are now scarcely intelligible; and he is not only no longer able to feed himself, but when the food is conveyed to the mouth, so much are the actions of the muscles of the tongue, pharynx, and & c. impeded by impaired action and perpetual agitation, that the food is with difficulty retained in the mouth until masticated; and then as difficultly swallowed. Now also, from the same cause, another very unpleasant circumstance occurs: the saliva fails of being directed to the back part of the fauces, and hence is continually draining from the mouth, mixed with the particles of food, which he is no longer able to clear from the inside of the mouth.

Question: *Why does this elegant description omit the cogwheel rigidity that was later described by Duchenne? Write down your answer before consulting Appendix 26.3.*

Auscultation. Changes in muscle activation by the brain are reflected in changes in muscle sounds. In healthy individuals, auscultation over the belly of the extensor muscles of the wrist reveals a muscle-activity sound at 40 to 50 Hz during strong extension. In patients with Parkinson disease, this normal rhythm is lost and replaced by rhythmic bursts at 10 Hz, barely audible with a stethoscope when the higher frequency sounds are absent. The sound has been compared to the noise of a distant helicopter. Normal frequencies are restored with effective treatment (Brown, 1997b).

Parenthetically, another application for the technique of auscultation over the muscles is a newly described diagnostic sign for primary orthostatic tremor. In this disorder, a fine tremor in the muscles of the lower limbs leads to a striking sense of instability when standing. The tremor is not present when the patient is walking or not weight bearing. Its frequency is around 15 Hz, and it cannot be reliably seen or palpated. Listening with the diaphragm of the stethoscope over thigh or calf muscles, especially the quadriceps or the hamstrings, reveals a thumping sound like the noise of a distant helicopter (Brown, 1995).

A Cautionary Note

One must be very cautious not to misdiagnose early Parkinson disease as some form of psychiatric illness. For instance, the shaking and the pill-rolling may get worse under emotional duress but improve when the patient is removed from the actual or threatened noxious situation. Even the oculogyric crisis of postencephalitic parkinsonism (basically a spasm of upward gaze) can be delayed by the patient for a considerable period of time. (Sacks described a case in which the patient had her crises regularly on Wednesday but was able to delay until Thursday when informed in advance that the students' visit would be a day late that week.) And finally, there is the kinesic paradox of Souques in which the patient can perform under noxious circumstances activities that had been lost in the course of the disease. For example, one immobilized patient in the pre-L-dopa era suddenly ran into his burning home to successfully rescue a valued object of great weight; following this, he again became immobile. It is easy to see why the neurologically inexperienced could misinterpret some or all of these facts.

Diagnosticity of Various Symptoms and Signs

Symptoms that significantly increase the likelihood of Parkinson disease when present, and decrease it when absent, include trouble turning in bed, shuffling while walking, micrographia, difficulty rising from a chair, loss of balance, and difficulty opening

jars. The glabella tap sign has a positive likelihood ratio (LR) of 4.5 and a negative LR of 0.13. A softer voice has a positive LR of 3.4 and a negative LR of 0.45. Various LRs have been tabulated (Rao et al., 2003). Not all symptoms and signs of parkinsonism have been studied from an "evidence-based" statistical perspective. Cogwheel rigidity, for example, is not included by Rao et al.

Drug-Induced Movement Disorders

Obviously, any drug that can block striatal dopaminergic receptors can result in an imbalance between the dopaminergic and cholinergic systems in such a way that the dopaminergic system is relatively defective. Thus, dopaminergic blockers, including but not limited to the phenothiazines, can acutely produce a picture that mimics parkinsonism. The cure is obviously to inhibit the cholinergic system by the administration of an anticholinergic drug.

Technically, the above movement disorder could be called a *dyskinesia*, which simply means an abnormality of movement. However, dyskinesia has been adopted for another movement disorder, *tardive dyskinesia*, which is biochemically the opposite of drug-induced parkinsonism. It tends to come on in patients who have been on chronic dopaminergic blockade, which is being withdrawn or diminished. (Sometimes, the dosage has not been changed but the dopaminergic system just seems to age and to exhibit tachyphylaxis. Often, these patients are also receiving chronic anticholinergic medication.) At this point, tics and dyskinesias of various types suddenly emerge. In this case, the treatment is to increase dopaminergic blockade (the "hair-of-the-dog-that-bit-you" approach) and/or to increase cholinergic activity—the exact opposite of the approach to the drug-induced parkinsonism discussed above.

Because these two movement disorders have exactly opposite biochemical causes and treatments, a word about nomenclature is in order. "Tardive" means late or after a long period of treatment. It is used to highlight the fact that tardive dyskinesia (which can almost be thought of as dopaminergic-blocker withdrawal) comes on after a long period of time.

Similarly, "dyskinesia" can and should be modified by indicating the muscle groups involved. The classic flycatcher dyskinesia, wherein the tongue darts in and out of the mouth like that of a frog catching flies, should be called a *buccolingual dyskinesia*; if it is a *tardive* dyskinesia, this word should be added to the description.

"Dyskinesia" by itself does not imply a specific etiology and it should not imply only a facial or lingual dyskinesia. For instance, some patients with tardive dyskinesia can present with chest, abdominal wall, or diaphragmatic spasms.

In any patient presenting with a movement disorder, a careful drug history is mandatory. A number of drug-induced movement disorders are summarized in Table 26.6. Consider prescription drugs, illicit drugs, and potential interactions. Cocaine use is a major risk factor for the development of acute neuroleptic-induced acute dystonia (van Harten et al., 1998). The "crack dance," well known to drug abusers, is seldom reported to physicians (Diederich and Goetz, 1998).

Not all dyskinesias in patients receiving drug therapy are caused by the medication. A review of case records of neuroleptic-naive patients showed abnormal involuntary movements in up to 28% of schizophrenic patients. Definite dyskinesias were described in 14.9% of 94 schizophrenic patients compared with only 1.7% of nonschizophrenic patients. Oral-facial movements were the most common type, being seen in 19% (Fenton et al., 1997).

Coordination

Posterior Column Signs (or Signs Potentially Related to the Posterior Columns)

The posterior columns carry the tracts conducting vibratory and position sense up to the higher centers. Therefore, an examination of the posterior columns' integrity really begins with the peripheral examination of vibratory and position (proprioception) sensations (*vide infra*).

Other tests of the posterior columns, especially of proprioception, may also test cerebellar and vestibular functions. A general principle is that if the patient can perform the task with his eyes open (visual cues available) but not with his eyes closed, it is a sign of impaired proprioception (posterior column disease); but if the individual cannot perform the test even with his eyes open, it is a sign of vestibular-cerebellar dysfunction.

The importance of position sense, taken for granted, is only appreciated if it is lost; see the tale of the "disembodied lady," who could function only by visual cues. A severe sensory neuropathy of this type may be caused by poisoning with enormous quantities of pyridoxine (Sacks, 1985).

The Romberg Test[11]

A Method

1. Have the patient stand with his feet together and with his arms at his sides.
2. Stand nearby, not touching the patient but ready to catch him if he falls.
3. Observe the patient for about 20 seconds.
4. Tell the patient to close his eyes. Continue the test for another 30 seconds.

Interpretation. As noted above, the ability to maintain posture only with the eyes open is evidence of impaired proprioception. But if the patient falls even with his eyes open, the test is positive for cerebellar and vestibular disease. (It is stated that if the patient falls repeatedly to one side, that is a sign of ipsilateral cerebellar disease; however, in the course of the required repeated testing, many patients learn that they will fall to that side and thus sometimes overcompensate by going to the other side in a lurch. Accordingly, it is suggested that if cerebellar disease is suspected on the basis of the Romberg test, the examiner should immediately proceed to some of the more specific and sensitive cerebellar signs described below.)

False Positives

Malingerers will also fall but they will first flex their knees and engage in other activities to lower the center of gravity and decrease the painful impact. When they learn that they will be caught and

[11] Romberg wrote the first neurology textbook. Prior to his work, there was only Morgagni's notebook.

TABLE **26.6** *Drug-induced movement disorders*

Disorder	Mechanism[a]	Drugs
Acute dystonia (oculogyric crises, oromandibular dystonia, opisthotonos)		Neuroleptics (dopamine receptor blockers)— Sulpride, domperidone, metoclopramide, prochlorperazine
		Buspirone
		Sumatriptan
Choreoathetosis		Birth control pills (rare)
	Underlying structural lesions may predispose to focal reactions	Anticonvulsants (phenytoin, carbamazepine, felbamate, gabapentin)
	Blocks dopamine reuptake, may influence postsynaptic receptor sensitivity	Cocaine
	Potentiate dopamine transmission; affect second messenger	Lithium
Akathisia (daytime restlessness; inability to keep legs still)		Dopamine receptor blockers (20%–30% of exposed subjects)
		SSRIs
Tics		Methylphenidate, pemoline, amphetamines, Sertraline
		Cocaine
		Antidepressants (tricyclics, SSRIs, bupropion) may worsen tics
		Anticonvulsants (carbamazepine, phenytoin, phenobarbital)
	Cholinergic–dopaminergic imbalance	Antihistamines, anticholinergics (uncommon)
Drug-induced parkinsonism	**Cellular level**	
	Mitochondrial	Calcium channel blockers
	Respiratory chain dysfunction	Valproic acid
	Dopamine receptor level	
	Presynaptic dopamine depletion	Reserpine, tetrabenazine
	False transmitter	Methyldopa
	D_2 receptor blockade	Dopamine receptor blockers, antiemetic agents, tetrabenazine, calcium channel blockers
	Motor circuitry level	
	GABA–ergic overactivity	Valproic acid
	Cholinomimetic action	Tacrine, bethanechol
	Complex and/or unknown	SSRIs (Leo, 1996)
Essential tremor or exaggerated physiologic tremor		Sympathomimetics
		Theophylline
		Tricyclic antidepressants
		Lithium
		Valproic acid
		Cyclosporin A
		Amiodarone
		Amphetamine
		Alcohol withdrawal
		Caffeine
Asterixis		Carbamazepine (combination therapy with lithium and clozapine)
Cerebellar tremor		Metoclopramide
Tardive dyskinesia		Antihistamines, fluoxetine, other SSRIs, tricyclic antidepressants (isolated cases)

[a]Mechanisms are far more complex than indicated here.
SSRIs, Selective serotonin reuptake inhibitors.
From Diederich NJ, Goetz CG. Drug-induced movement disorders. *Neurol Clin North Am.* 1998;16:125–139 and Kumar R, Lang AE. Secondary tic disorders. *Neurol Clin North Am.* 1997;15:309–331, with permission.

protected, they may bend into the protecting examiner from the waist, keeping the legs straight. However, if they are not certain that they will be caught, they may simply collapse in a heap, straight down and not to one side or the other.

False Negative

The Romberg test was previously known to Morgagni. Romberg reinvented it because his practice as a neurologist was greatly concerned with tabes dorsalis. Nowadays we do not see much tabes, but we see a lot of diabetic neuropathy. This leads to an important false negative: The modern diabetic may have lost position sense in his toes but still have position sense at the ankles and thus be able to perform the Romberg test perfectly.

Cerebellar Signs or Predominantly Cerebellar Signs or Potentially Cerebellar Signs

Also see Chapter 10 and earlier in this chapter for nystagmus, the section on "Gait" in this chapter, Table 26.1 and accompanying discussion for the eye signs of acute cerebellar hemorrhage, and "Freebies" at the end of this section.

Dysdiadokokinesia

Dysdiadokokinesia is clumsiness in performing rapid alternating movements, such as alternating pronation and supination of the hands, or difficulty with the tongue movements required to pronounce "k," "t," or "cu."

A Method

1. Tell the patient to imitate you, and begin by rapidly (150 times per minute) patting your own chest with both hands, using, say, the radial side of each hand.
2. While watching the patient's imitation, increase the speed, looking for differences in rate, range, amplitude, and direction between the patient's two sides (a very sensitive test of unilateral cerebellar disease in itself).
3. Next, begin alternating the side of the hand striking the chest, going to the ulnar side for 10 beats and then back to the radial side for 5 beats and finally alternating sides on each blow. Watch the patient to see if one side "lags behind" or falls out of rhythm. Of course, any limb or set of alternating movements may be used (though forearm rotation is generally best) but the test should always be done bilaterally.

Another Method

Ask the patient to repeat "Topeka" or "Katy, K-Katy" as fast as possible.

Interpretation. Abnormalities of rate, range, amplitude, and direction occur only in cerebellar disease, so the predictive value of a properly performed positive test is quite high.

Sometimes it is easier to make a determination by listening, not just to "Topeka" but also to the hand-patting test (steps 1 and 2 above). Are rhythm and amplitude maintained, or do you hear a ritardo and diminuendo?

False Negatives

Wiener and Nathanson (1976–1977) note that many physicians miss unilateral cerebellar disease through not having the patient perform with both hands at the same time. Such a failure obviously deprives the physician of his control side.

False Positives

A false-positive test should be considered a possibility any time the test for dysdiadokokinesia is positive and other cerebellar tests are negative. This can occur in the nondominant hand, which is often less skilled at fine motor performance than the dominant side. It can also occur with frontal lesions that produce apraxia, owing to the fact that the cerebellum, whose posterior lobe receives its major projections from the frontal lobe, is thus rendered "deaf" (i.e., suffers sensory deprivation).

The Heel-to-Knee-to-Shin Test

A Method

1. Tell the supine patient to place one of his heels on the opposite knee and then to slide the heel all the way down the shin to the big toe.
2. Repeat with the other heel.

Interpretation. Patients with cerebellar disease cannot do the heel-to-knee-to-shin test. If the cerebellar disease is unilateral, the impairment will only be seen with the ipsilateral heel.

As with many of the vestibulocerebellar tests, the heel-to-knee-to-shin test may be converted to a proprioception-posterior columns test by having the patient also perform it with his eyes closed. Patients with cerebellar disease will have an abnormal test with the eyes closed or open; but patients with proprioception-posterior columns disease will be markedly improved with the eyes open.

Norman Bass Razor. Repeat the heel-to-knee-to-shin test on both sides, insisting that the heel be *exactly* 1 in. above the shin. The induced "locking" of the hip joint actually improves the performance of this step in patients with cerebellar ataxia but does not improve the performance of the test in persons with other causes of poor performance such as malingering.

The Finger-to-Nose Test

A Method

1. Hold your finger in front of the patient's face, far enough away that he must fully extend his arm to touch it, and instruct him, "Touch my finger with your right forefinger."
2. After he does this, say, "Now touch your nose."
3. Repeat several times with your finger in the same place.
4. While the patient is moving his finger back to his nose, relocate your own target finger in a different quadrant.
5. After he touches his nose, say, "Now touch my finger again."
6. Repeat steps 4 and 5, randomly varying the target, each time causing the patient to extend his arm fully. Increase the speed slightly and do about five trials.
7. Repeat the whole procedure with the patient's other hand.

Interpretation. Look for *cerebellar ataxia*, which will be manifested by a jerky, asynergic pointing at the target finger of the examiner. Also look for *dysmetria* (abnormal movement/judgment of distance), which will be manifested by missing the target through lateral displacement at termination of the movement.

Dysmetria is found not only in cerebellar disease but also in upper-extremity proprioceptive disease (which is somewhat rare, occurring in tabes dorsalis and untreated pernicious anemia) and in vestibular disease.

But if upper-extremity position sense is intact and there are no vestibular signs elicitable, then this is an excellent test for cerebellar disease. In that case, if the abnormalities noted above are found only on one side, then the patient has ipsilateral hemispheric cerebellar disease. (If the signs are abnormal *bilaterally*, the patient has either bilateral cerebellar hemispheric disease or disease of the midline cerebellar structures.)

In unilateral disease, if the test is done rapidly with alternate hands, the "bad" hand will drift or drop toward the floor during the "good" hand's turn (while the "bad" hand is waiting its turn).

A Different Response. Overpointing can be a sign of loss of depth perception (e.g., in parietal lobe dysfunction; see later in this chapter).

Because the subject must be allowed to look at the target finger, the test in its present form does not lend itself to repetition without visual cues; therefore, an alternate method is described to permit the differentiation of cerebellar and vestibular disease.

An Alternate Method

1. Have the patient extend his arm laterally. The movements here are initiated with the patient looking straight ahead and therefore lacking visual cues.
2. With flexion permitted only at the elbow joint, ask him to place his forefinger on the tip of his nose.

This test could be modified to permit visual cues by having the patient rotate his head toward the side of the tested forefinger.

Truncal Ataxia

Whereas limb ataxia is a sign of unilateral cerebellar hemisphere disease, truncal ataxia is a sign of disease of the posterior vermis and archeocerebellum. It is not necessary to get the patient to stand up for this, an important point because many of the patients so afflicted are unable to get out of bed. Even if the patient can simply be made to sit up in bed, patient observation will often be rewarded within 30 seconds by a torso that sways like a palm tree in a gusting wind.

Alternately, if the patient can sit on the side of the bed, sit down next to him. Healthy patients will adjust their position; patients with truncal ataxia will not. This may be the first or only sign to occur in children with posterior midline tumors (S. Horenstein, *personal communication*, 1988).

The Rebound Phenomenon of Stewart and Holmes

A Method

1. Have the patient flex his arm at the elbow, and attempt to extend it against the examiner's resistance, as during the testing of triceps strength.
2. Suddenly release the resistance.

Interpretation. If the arm goes into *complete* extension, with a force jerking the patient upward and forward, the test is positive. This is, of course, just one more test of the *impaired reciprocal inhibition* seen in cerebellar disease because normally one can stop the contraction of the extensors and initiate the contraction of the antagonistic flexors prior to reaching full extension.

Other authors' instructions to the contrary, this test should not be done in the opposite direction (as during testing of the biceps' motor strength) as the patient with cerebellar disease may strike himself in the face. Although this has been used as a test for malingering (because the malingerer has normal reciprocal inhibition and so will not strike his own face), it is a test for *cerebellar* malingering only. Contrary to some opinion, the absence of flexion rebound in a patient with simple asthenia of that upper extremity does not prove malingering. It simply proves that the patient has no detectable cerebellar disease.

Freebies

There are other cerebellar signs that may be casually noticed during the examination of the patient but that are not usually specifically sought.

1. *Cerebellar speech* is irregular, jerky, and briefly monotonous and slow, with sudden punctuations by explosive increases in rate and volume, as if a poorly tuned motorcycle were speaking.
2. After the patellar jerk has been elicited, the leg will continue to swing back and forth several times before it comes to rest. (*Before* eliciting the knee jerk, make sure there is room for the leg to swing back, should this sign be present.) This is called the *pendular knee jerk*. (The test also works with the triceps jerk.) It is the best test for hypotonia, which may also be noted by the experienced examiner during muscle testing.
3. Eye signs of cerebellar hemorrhage have been listed in Table 26.1.

The cerebellar signs are intellectually appealing for two reasons. First, they are easy to learn to perform; and second, when one of them is present, others usually will be found. (This is true for clinicians beginning with the patient and progressing toward the diagnosis. If one begins with the CT scan and then tries to reason back to the physical, one can occasionally find a cerebellar metastasis that has not yet caused any physical findings.)

Vestibular Signs and Predominantly Vestibular Signs

The Oculocephalic ("Doll's Eye") Reflex

Also called *Bielschowsky doll's-head eye reflex* (the original term), the doll's head, the doll's eye sign or maneuver, or the oculocephalic reflex, sign, or maneuver, this is a useful test in comatose patients in whom there is a question as to whether the midbrain and its reflexes have been preserved.

In a comatose patient over 6 months of age with an intact midbrain and vestibular reflexes, the eyes will maintain the original direction of gaze as the patient's head is passively turned. This means that the eyes are fixed on the same point in the room as the patient's head is moved, which means that the globes move within the head proportionally to the movement of the head but in a direction opposite to the passive motion of the head. If you stare at the right edge of this page as you rotate your head to the left, you are maintaining the "original direction of gaze."

Interpretation. The slow rotation activates the vestibular apparatus, which provides input to the midbrain, which instructs the extraocular muscles to move the globes so as to maintain the original direction of gaze, as if the patient were still focusing on an object. But if there is midbrain damage or dysfunction (specifically in the

area of the MLF from the horizontal gaze center in the abducens nucleus in the lower pons to the oculomotor nucleus in the midbrain), these reflexes are lost, and passive rotation of the head will not result in movement of the globes to maintain the original direction of gaze. Rather, the eyes will continue to stare in whatever direction the head is pointed. It is as if they were painted onto the skull.

Caveats. Because the doll's eye test involves the passive rotation of the skull in a patient who is unconscious, we must remember to assure ourselves of the integrity of the cervical vertebrae before performing this test. Thus, this maneuver is generally neither useful nor advisable in the evaluation of patients in the emergency room (M. Faria, *personal communication*, 1998). If one cannot be assured of the absence of a neck injury, one should proceed directly to caloric testing.

This test is generally done only in comatose patients. Patients who are awake will have doll's eyes, or not, depending on whether they have fixed their gaze or are looking wherever you turn their head.

For the Advanced Student. The oculocephalic reflex also operates in the vertical direction ("setting sun sign") and it has been so used in the study of paralysis of upward voluntary gaze (see earlier in this chapter).

A Note on Recording the Findings. A report that the "doll's eye test" is "positive" or "negative" may be misunderstood. The term refers to dolls with mobile, weighted eyes that maintained their position as the doll's head was turned. This author remembers thinking, during a demonstration of an intact oculocephalic reflex: "But dolls' eyes don't do that." All her dolls had had fixed or painted-on eyes.

The shorthand terminology that is least confusing to this author is to say "oculocephalic reflexes intact (or preserved) bilaterally" (meaning that the eyes maintained their original direction of gaze on lateral rotation of the head to one side and the other) or to describe what happens if this is not the case (such as "the position of the eyes remained fixed with respect to the head on rotation to either side").

Perhaps it is easiest to remember that dead people's eyes do not move. The usual reason for testing the oculocephalic reflex is not to test for an obscure lesion in the medulla or midbrain or connections in between but to check for brain death (*vide infra*).

The Vestibular Finger-to-Nose Test

This is a test of upper-extremity proprioception of the cerebellum and of the vestibular apparatus. Because upper-extremity proprioception is usually normal (as can be independently determined; see position sense testing presented later in this chapter), this is used as a test for the cerebellum and the vestibular apparatus. For the latter, the test is used in conjunction with one of the vestibular stimulation tests (calorics and the various motion tests, *vide infra*).

A Method

1. Have the patient touch your fingertip, as in the original version of this test presented earlier in this chapter.
2. After he touches your finger, have the patient touch his nose as before.
3. Tell him to close his eyes.
4. Immediately ask him to touch your (unmoved) finger again.

Interpretation:

1. With cerebellar disease, the patient will probably show a cerebellar intention tremor.
2. If the lesion is not unilateral, the patient will "past point" on either side (randomly) an equal number of times. With unilateral vestibular or cerebellar disease, the patient will past point only to one side.

Spontaneous Nystagmus

Before performing the tests for induced nystagmus (*vide infra*), check for baseline nystagmus (review Chapter 10 for a description of various types of nystagmus and for additional comments).[12] In the awake patient, nystagmus has two components: the fast (jerk) cerebral component and the slow vestibular component.

If there is a destructive lesion of one vestibular nerve or labyrinthine apparatus, there may be a spontaneous nystagmus in which the slow component looks at the diseased side. This simple observation has saved a lot of people a lot of time.

If the fast component is always in the same direction (regardless of whether the eyes are looking to the left or the right), the lesion is labyrinthine. If the fast component changes direction with changing direction of gaze, always showing the fast component in the direction of gaze, then the problem is not labyrinthine but in the brainstem (including drug intoxications).

Vertical nystagmus always signifies a lesion in the brain. It is usually secondary to a midline lesion or to Wernicke encephalopathy. It can be a sign of acute beriberi, usually precipitated by administering glucose to a thiamine-deficient alcoholic. This requires urgent administration of intravenous thiamine. It is better to avoid this emergency by generous use of thiamine in all high-risk patients.

Upbeat vertical nystagmus in the primary position, accentuated by upward gaze, points to a lesion in the anterior cerebellar vermis or the medulla, as in the medial medullary syndrome. This syndrome results from vascular occlusion; two cases secondary to fibrocartilaginous embolism to the anterior spinal artery and its branches, presumably from the nucleus pulposus of an intervertebral disc, have been described (Kase et al., 1983).

If nystagmus is present only and always together with vertigo, then the patient has vestibular disease, and thus may have Ménière disease. However, if the nystagmus and vertigo are dissociated, Ménière disease is excluded because the lesion must be in the brainstem (S. Horenstein, *personal communication*, 1988). With Ménière syndrome, there is no nystagmus between spells with eyes open but it may be present with eyes closed (Alford, 1972).

Nystagmus on rapid rising results from disease in the posterior semicircular canals, not the brainstem. Thus, it is important to make the physical examination appropriate to the history. If the patient complains of vertigo (not light-headedness) on rapid rising, have him stand up quickly and check whether nystagmus occurs at the same time (S. Horenstein, *personal communication*, 1988).

Rotatory nystagmus is a classic sign of BPPV (see discussion of Dix–Hallpike maneuver below).

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[12] Also see Chapter 4 for instructions about the *naming* of nystagmus. In this chapter, the convention of neurology tests will be followed when possible: The nystagmus is named for the fast component.

Downbeat nystagmus is presumptive evidence of dysfunction at the lower end of the brainstem or cerebellum. Structural causes include platybasia and the Arnold–Chiari malformation. Metabolic causes include magnesium depletion, lithium intoxication, alcoholic cerebellar degeneration, Wernicke encephalopathy, anoxia, and anticonvulsant toxicity (phenytoin or carbamazepine). Inflammatory causes include encephalitis and syphilis. Other causes include hereditary and paraneoplastic cerebellar degeneration, encephalitis, brainstem infarction or vertebrobasilar insufficiency, brainstem compression from cervical involvement in rheumatoid arthritis (Menezes et al., 1985), MS, and bilateral internuclear ophthalmoplegia (Alpert, 1978; Chrousos et al., 1987; Cogan, 1968).

Monocular nystagmus almost always signifies pontomedullary disease.

In *seesaw nystagmus*, one eye goes up and intorts as the other eye goes down and extorts, most prominently when the patient is fixating. It is usually associated with severe visual field defects. The lesion usually is in the rostral part of the mesencephalon, probably involving the interstitial nucleus of Cajal (L. Huntoon, *personal communication*, 2004).

Caloric Testing (Oculovestibular Reflexes)

To test the integrity of the labyrinthine apparatus, the midbrain, and the oculomotor efferents, heat and cold are used to induce thermal currents in the vestibular endolymph. These in turn produce nystagmus, provided that the neural tissue specified above is intact.

A Method

1. If the patient is supine, tip his head forward about 30 degrees. This ensures that you get maximal stimulation of the horizontal canals and so produce horizontal nystagmus.

   For the Conscious Patient. If the patient is sitting, tip his head back about 60 degrees. If you leave his head upright, you will get maximal stimulation of the vertical canals, which produces rotatory nystagmus. Having the conscious patient wear a pair of strong convex lenses prevents him from accommodating to the stimulus by visual fixation, yet still permits the examiner to see the nystagmus. Alternately, Dr Broadwater of Missouri simply has the patient close his eyes; nystagmus can be detected from the corneal bulges in the lightly closed lids.

   This test may cause the conscious patient to vomit. Be sure to have a bucket close by.

   Cerebellar nystagmus, unlike caloric nystagmus, is not position dependent.
2. Pour 100 mL of very cold water in one of the external canals after you have assured yourself that there is no perforation of the tympanic membrane and that the canal is free of cerumen. If cerumen keeps the cold water from reaching the tympanic membrane and setting up a current in the endolymph, the result will be a false-negative test.

   Comment. The purpose of the ice water is not to give the patient frostbite of the tragus but to set up a thermal current in the endolymph. If you use cool water (20°C), you can eventually get the same effect but it will require about a quart of water. With ice water, you can get a nice effect with only 5 to 30 mL, starting in about 20 to 30 seconds and lasting about 1 minute.

   The same thing goes for warm water, should you care to use it. You can use a quart of 50°C water or smaller volumes of hotter water. The fact that this test is usually performed on unconscious patients should not encourage you to scald the tympanic membrane; test the temperature against the back of your hand.
3. *Look for nystagmus in the conscious patient or deviation of the eyes in the unconscious patient*. In the conscious patient, the cold-induced slow component comes toward the stimulated ear and the fast jerky compensatory cerebral component, for which the nystagmus is named, moves opposite. With warm water, the directions are reversed. (Thus, the mnemonic COWS = cold opposite, warm same.)

Interpretation:

1. In unconscious patients, there can be no nystagmus because there is no fast cerebral component. *The unopposed slow cerebellar/vestibular component appears as tonic deviation toward the cold side*. If both sides are stimulated with cold, the eyes look downward (Plum and Posner, 1972).
2. In conscious patients, the absence of thermally induced nystagmus on just one side means that a destructive lesion (labyrinth or vestibular nerve) is ipsilateral. The absence of an inducible response bilaterally means that there is bilateral disease, which by Occam's razor is probably in the brainstem.
3. In conscious patients, a trick for amplifying the nystagmus so that it is more easily seen is to have the patient look to the side away from the cold-stimulated ear rather than straight ahead.

   Lateral past pointing and falling, which can be checked for at the same time, are, however, still *toward* the side of the cold irrigation.
4. Some lesions such as expanding tumors, abscesses, vascular aneurysms, and so forth, initially go through an irritative phase before they become destructive. At this point, there is simply an exaggeration of all normal responses. For instance, cold stimulation of the diseased side will produce nystagmus (fast component to the healthy side), which can be accentuated on lateral gaze to the healthy side. There is also falling and past pointing to the afflicted side. This phase of the disease does not usually last long but can occasionally be confusing if one does not know about it.

Fortunately, electronystagmograms have now generally replaced caloric testing, which is miserably uncomfortable.

The Bárány Chair Test

If you can find an old-fashioned barbershop chair with a headrest and a spinning base, you can try this one. (A Veterans Administration hospital may have a barbershop with such a chair.) A desk swivel chair with arms could also be used.

A Method

1. Instruct the patient to close his eyes and place his head against the headrest, which is tilted 60 degrees backward (from vertical) or 30 degrees forward (from horizontal).
2. Spin the chair to the patient's right 10 times, as fast as you can, and abruptly stop it with the patient facing you.
3. Tell the patient to open his eyes.

4. Normally, the patient will have nystagmus with the slow component going to the right (the direction in which the patient was spun).
5. If the patient attempts to stand, he will fall, or more commonly will lean to his right while seated.
6. Hold a finger up directly in front of the patient and ask him to touch it with his forefinger. Normally, he will past point to his right.
7. Repeat, spinning the chair to the patient's left.

Interpretation:

1. Destructive lesions cause the absence of the normally elicited responses (steps 4 to 6 above).
2. If only some of the responses are lost, the patient may have an intramedullary lesion.
3. Various other interpretations of these tests have been offered without any good data from large series. The availability of computerized tomography and nuclear MRI increases the opportunity for definitive analysis of all patterns of response, but at the same time has decreased performance of these clinical tests for cerebellar and midbrain lesions, which can now be imaged *in vivo*.

The Drop Test (Dix–Hallpike Maneuver)

This test, which has also been called the *Bárány or Nylen–Bárány maneuver*, is a unilateral vestibular stimulation test for BPPV. It should be done routinely in all patients complaining of vertigo. BPPV is the most common and the most easily treatable cause of dizzy spells.

A Method

1. Have someone stand on each side of the examining table when you perform the maneuver. Some patients develop severe vertigo, lose their bearings, and can fall off the table. It is prudent to have a bucket nearby as patients occasionally vomit.
2. Have the patient seated so that when he lies down, his head will extend over the end of the examining table.
3. Explain to the patient what is going to be done and that any dizziness will only last a few seconds.
4. Maintain control of the patient's head to be sure the maneuver is performed optimally so as to provide maximal stimulation. Place one hand on top of the head and one hand under the chin.
5. On the count of "one, two, three," have the patient go quickly from the sitting to the supine position, as you quickly turn his head toward you, stimulating the posterior semicircular canal. Tell the patient, "Keep your eyes open and look directly at me." The natural tendency to close one's eyes at the sudden onset of vertigo could cause you to miss the rotatory nystagmus that may only last a few seconds.
6. Observe the patient's eyes for at least 15 seconds to see whether nystagmus is induced. Be attentive because the nystagmus may last only a few (from 2 to 30) seconds.
7. Slowly bring the patient to a sitting position, with the head still rotated, and check for nystagmus again.
8. Repeat, with the head rotated to the opposite direction. (The "down" ear is the one being tested.) If the patient can tell you which side down causes the vertigo, check the opposite side first to minimize nausea.

Interpretation. Whichever down side produces nystagmus is the "affected" side causing the positional vertigo.

With labyrinthine disease, there is a 4- to 5-second latent period between the movement and the onset of nystagmus. The nystagmus is primarily torsional but may have some vertical components. The results are prominent and dramatic. In some cases, the test is strongly positive only the first time that it is performed, with the response fatiguing rapidly.

The test does not always induce nystagmus in BPPV; the sensitivity is reportedly from 50% to 78%. A positive test combined with a history of either vertigo or vomiting gives an LR of 7.6 for a peripheral, nonemergent form of vertigo. If one or more of these features are lacking in a "dizzy" patient, the LR for peripheral, nonemergent vertigo as opposed to a potentially emergent and/or central cause is 0.6 (Froehling et al., 1994).

In brainstem disease, there is no latent period, and the nystagmus may be purely vertical.

Cerebellar infarction could masquerade as a peripheral vestibular lesion because vertigo and severe imbalance may be the only presenting features. If this lesion is suspected, neuroimaging is required on an urgent basis. Because the distinction is so critical, patients should try to stand and walk even if it is very uncomfortable. Patients with a peripheral lesion should be able to walk during the acute phase, whereas those with a central lesion often cannot stand to take a single step without falling (Baloh, 1998a,b).

Semeiophysiology. The stereotypical quality of the response gives a clue to the origin of the disorder. BPPV results from the free movement of particulate debris (calcium carbonate crystals called *otoconia*) in the semicircular canals, almost always in the posterior portion. The particles may dislodge, either spontaneously or as a result of head trauma, from a membrane in the utricle. Their weight helps the body sense gravity. The latency before the onset of nystagmus results from the time required for the particles to start moving under the influence of gravity. Nystagmus ceases when the particles come to rest. This mechanism suggests the treatment, the Epley maneuver.

The Epley (Canalith Repositioning) Maneuver. If the Dix–Hallpike maneuver produces a positive result, some physicians immediately undertake the Epley maneuver, which rotates the patient's head so that the loose particles slide out of the posterior semicircular canal into the utricle. If the vertigo occurs with the right ear facing downward, the physician waits for the vertigo to stop, then rotates the patient's head to the left, with the right ear facing upward. After holding the head in that position for 30 seconds, the physician asks the patient to roll over onto his left side.

Meanwhile, the physician rotates the patient's head to the left until the nose points toward the floor and holds that position for 30 seconds. Finally, the physician lifts the patient into a sitting position with the head still facing left. For vertigo occurring with the left ear down, carry out the same maneuver with appropriate modifications. If necessary, the maneuver can be repeated several times until the nystagmus is gone.

Usually, if the diagnosis is correct the maneuver produces a dramatic cure. To prevent recurrence, the patient is cautioned not to lie flat for a few days, or not to bend down, tilt the head backward,

make quick head-turning movements, or sleep on the affected side.

Dr Lawrence Huntoon teaches patients and family members how to do this maneuver themselves. It is important to take precautions against patients falling off the table.

A number of variations on the method have been described.

Head Thrust Test

This test assesses the vestibulo-ocular reflex (VOR), which is checked in comatose patients with the doll's eye or caloric test.

A Method

1. Stand in front of the patient and grasp his head in both hands.
2. Instruct the patient to look at your nose.
3. Quickly move the patient's head 5 to 10 degrees to one side and observe the eye movements.
4. Repeat for the other side.

Interpretation. A normal response is for the patient's eyes to stay on target (the examiner's nose). When there is a lesion of the VOR on one side, a corrective eye movement (i.e., a corrective "saccade") back to the examiner's nose is seen after the head is moved *toward* the affected side. These features can be appreciated even when spontaneous nystagmus is present. A patient with unidirectional nystagmus, a positive head thrust in the direction opposite the fast phase of nystagmus, and no other neurologic features can be diagnosed with vestibular neuritis, a peripheral lesion, with a high level of certainty (Kerber 2009).

A Note on Vertigo

Dizziness is the third most frequent complaint in a study of patients presenting at a general internal medicine outpatient clinic. Vertigo was the most frequent category of dizziness (Froehling et al., 1994).

It is important to distinguish peripheral causes of vertigo (the labyrinth or eighth cranial nerve) from central nervous system causes.

The differential diagnosis of central causes includes vertebrobasilar ischemia, cerebellar infarction or hemorrhage, brain tumors, MS, or migraine. A careful neurologic examination is indicated.

Nonbenign peripheral causes include cholesteatoma and acoustic neuroma. Do not neglect to examine the ear and check the hearing (also see Chapter 11).

Motor Examination

Testing of muscle strength has been described in detail in Chapter 25.

Intercostal Muscle Innervation Test

A quick way to determine motor function in the thoracic spinal levels is to place your hands laterally on the patient's rib cage, with your fingers between the ribs, and ask the patient to breathe deeply. You may need to move your hands cranially or caudally a few times to find the lowest working level. If a pair of ribs separates, there is some motor function; otherwise, there is not. False positives are possible from sternocleidomastoid or other muscles. In a complete T-6 paraplegic, Dr Edward J. Harshman, who developed this concept, reports being able to find a sharp line between working and nonworking intercostals. This method is more objective than the well-known sensory level for spinal cord injury. It also predicts sitting balance in stroke patients (E.J. Harshman, *personal communication*, 2004).

Fibrillation and Fasciculation

Though involving the muscles, these phenomena are signs of neurologic disease. In *fibrillation*, individual muscle fibers are firing spontaneously because they have lost their innervation. A *fasciculation* involves the entire motor unit: the nerve cell, the axon, and all the motor fibers that the unit innervates. Fibrillations are regular. On electromyogram (EMG) needle recordings, fibrillations sound like a ticking clock. Fasciculations, on the other hand, are very irregular and sound like a thump in the night (L. Huntoon, *personal communication*, 2004).

Fibrillations cannot be seen. Fasciculations in the tongue may cause it to resemble a bag of worms. Do not have the patient protrude the tongue; just have him open his mouth.

Fasciculations may be seen from time to time as muscle twitches in healthy persons. They can be caused by compression on a nerve root or irritation in an anterior horn cell.

Pernicious fasciculations have the following four characteristics:

1. They are stereotyped, that is, they always affect the same muscle fibers.
2. They are present at rest.
3. They may even be present at sleep.
4. They are perfectly rhythmic or periodic.

The patient may also have atrophy and/or weakness in the same muscles. Pernicious fasciculations may be seen in amyotrophic lateral sclerosis (ALS), syringomyelia, bulbar palsy, and progressive spinal muscle atrophy of whatever eponym.

A Note on Muscle Tone and Upper and Lower Motor Neuron Disease

A spastic paralysis, associated with muscle hypertonicity and exaggerated deep tendon reflexes, results from lesions of the brain or from interruption of the descending tracts. In contrast, lower motor neuron or peripheral nerve lesions produce a flaccid paralysis.

A spinal cord compression may give lower motor neuron signs in the muscles innervated by the compressed segment plus upper motor neuron signs on one or both sides below the level of the compression (Brain and Walton, 1969).

A combination of upper and lower motor neuron signs also occurs in ALS (or Lou Gehrig disease). The classic presentation involves fasciculations (as in the tongue) and muscle wasting (as in the intrinsic muscles of the hand), with increased reflexes and weakness in a pyramidal distribution (*vide infra*) and extensor plantar responses (*vide infra*).

Assessing Muscle Tone

As muscle tone is of practical importance in neurologic diagnosis, pendulousness of the legs was described as a simple and reliable office test (Wartenberg, 1951).

A Method

1. Have the patient sit with his legs hanging freely over the edge of an examining table that has no crossbar or other impediment to free swinging of the legs. Ask him to relax his legs.
2. Lift the patient's legs simultaneously to the same height, then release them, permitting them to swing freely. Or alternately, push them backward and suddenly remove your hands, allowing them to swing.
3. If the patient is interfering with the examination by tensing the muscles or voluntary motion, try to get him to relax by distracting his attention. The test cannot be used if relaxation cannot be achieved.
4. Observe for asymmetries, such as one leg swinging more times than the other, or for motion of the leg in any direction other than the anteroposterior plane.
5. To verify asymmetries, repeat the test several times.

Interpretation. In a healthy person, the legs usually swing six to seven times in a normal and regular movement. Extrapyramidal rigidity reduces the swinging time. In advanced cases, the legs may swing only once or twice or not at all. The test is most valuable in diagnosing unilateral parkinsonism.

With pyramidal spasticity, forward movements are brisker and larger in amplitude than backward movements, and movements are zigzag rather than in a precise anteroposterior plane. With hypotonia of any cause, such as lesions of the cerebellum or its connections, the swinging time of the affected leg is longer.

This test is to be distinguished from the "pendular reflex," or the continued oscillation of the leg after the patellar tendon is tapped. In contrast to the latter, the response to passive displacement does not parallel the strength of the reflex response. Also, the same degree of leg displacement each time is achieved more precisely than is the same force of tapping the tendon.

A Note on Hemiparesis

Localizing Cortical Lesions

The areas of the motor cortex controlling various parts of the body have been determined experimentally (Figs. 26-17 and 26-32).

Signs of Fatigue

Pronator Drift

Rather subtle weakness may be detected by having the patient close his eyes and hold both arms, palm up, extended at the wrist and elbow. The hand of the hemiparetic arm will tend to pronate.

The Barré Sign

Have the patient lie prone with his knees flexed at a 90-degree angle. The weak leg will tend to flex or extend further. False positives occur in cerebellar disease.

The Knee Dropping Test

This test is a sensitive way to detect mild weakness that has not been demonstrated by other methods. The test is based on the relative weakness of the flexors as compared to the extensors with pyramidal lesions (Wartenberg, 1953).

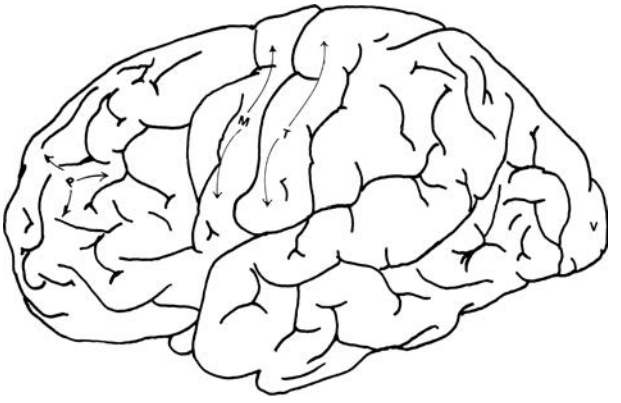


Figure 26-17 Major areas of the brain. P, the general area where lesions can produce changes in personality. (Such changes can also result from lesions in other areas.) M, the motor area, the precentral gyrus, located just in front of the central gyrus. T, the sensory area, which includes tactile sensation. It is not surprising that lesions in this area may lead to astereognosis. V, vision areas of the occipital lobe where lesions may cause blindness.

A Method

1. Have the patient lie supine on a firm, smooth surface.
2. Assure that the patient's heels can slide easily on the surface, as by applying talcum powder to the heels and the surface, or by placing a square of smooth cardboard under each heel, or perhaps by having the patient put on socks.
3. Flex the knees to form an obtuse angle. If the drop does not occur at first, try extending the legs a bit.
4. Give the patient no further instructions, and simply watch for the knee on the affected side to drop until the leg is flat on the surface. With conscious effort, the patient may be able to retard the drop for a period of time. Some patience must be exercised.
5. It is advisable to repeat the test whether positive or negative. It should be considered positive only if the dropping occurs repeatedly.

Distribution of Weakness

In pyramidal tract lesions, weakness is maximal in shoulder abductors, elbow extensors, wrist extensors, hip flexors, knee flexors (hamstrings), and dorsiflexors of the foot. Examiners who content themselves with testing the quadriceps and grip strength will miss early or mild disease; in almost all neurologic disorders, these two functions are the least likely to be affected. As expected from this pattern of weakness, the hemiparetic patient will walk with the elbow flexed and the arm and fingers flexed across the chest. The foot will tend to scuff along the floor (Patten, 1996).

Differentiation from Disorders of Higher Cortical Centers

Dr Bill Domm of Williamsburg, Virginia was wont to examine the shoes of patients claiming hemiparesis. If the patient was truly hemiparetic around the clock and not just in front of the doctor, the shoes would be worn asymmetrically in a manner congruent with the patient's observed gait.

Of course, some patients with disorders of the higher centers, such as a conversion reaction, may well be hemiparetic all of the time regardless of the doctor's presence. These are also the patients who may eventually develop a disuse atrophy of the concerned

muscles; this atrophy is misinterpreted as evidence that the patient does not have a disorder of the higher centers but rather a peripheral neuropathy.

One test that detects patients who are uncooperative or suffering from conversion, suggestion, or autohypnosis relies on the fact that persons with motor weakness (e.g., from a stroke) also lose the ability to perform slight, gentle motor exertions. Hold up something that will bend on the application of slight force, such as a calling card, an index card, a plastic ruler, or a wound piano string. Ask the patient to touch the top of it "as lightly as possible." Patients with motor weakness from stroke, for example, press down so hard that they visibly bend the object. Patients with the other types of diagnosis are able to touch it lightly.

Hysterical paralysis may be identified by its anomalous distribution; contraction of antagonistic muscles (detected by placing a finger on the biceps or patellar tendon and confirmed by electromyography); absence of muscle wasting and contractures except in cases of long standing (Brain and Walton, 1969); and absence of expected synkinesias (*vide infra*).

Synkinesias in Diagnosis of Paresis

A common trick for revealing the diagnosis of malingering is to get the patient to use a muscle group in one position after having claimed inability to use it in another. At the crudest level, this involves such maneuvers as telling the patient who had claimed the inability to flex at the knee, "You can pick up your pants now," following a rectal examination performed with the patient leaning over the examining table. But a more sophisticated and reliable method of making the same assessment is to check for the absence of the associated motor movements (synkinesias) that normally occur with certain activities (Table 26.7).

The simplest sort of synkinesia is swinging the arms during rapid walking. The absence of the same is a clue to Parkinson disease. Other synkinesias help distinguish various etiologies of paresis. Figures 26-18–26-21 are illustrations by Dr R. S. Lyman from Dr Leo Alexander's superb chapter on the neurologic examination in Pullen's *Clinical Diagnosis* (see Chapter 29). These should be studied now.

The Hoover sign involves the phenomenon of complementary opposition, described by Grasset and Gaussel. If a healthy individual in the recumbent position raises one leg up high, the other will press down on the examining table. The pressure can be quantitated by means of a manometer, with the rubber bulb placed under the heel; usually, however, the examiner simply places his hand under the heel. When a patient suffering from a neurologic hemiparalysis or weakness lifts the paretic leg or attempts to lift the paralyzed leg, the other leg will press down with great force. However, when he lifts the normal leg, the pressing down movement of the paralyzed or paretic leg will be absent or reduced respectively. The opposite is the case in malingered or conversion paralysis or weakness. When lifting the normal leg, the hysterically paralyzed leg will press down like a normal leg. However, when attempting to lift the "paralyzed" leg, the down-pressing movement of the normal leg will be absent or trifling, commensurate to the absence or paucity of the effort made.

The Hoover Sign as a Guide to Prognosis

The Hoover sign can also be used to help predict recovery of a paralyzed leg following a stroke because the synkinesia is a bilateral motor event originating in only one hemicortex (the good one). In fact, this is the way that Hoover initially used his test (whereas Barré used his test to check for conversion). (See the Barré sign, above.)

Ask the patient to raise the healthy leg, and keep your hand behind the heel of the weak leg to see if it presses down. If it does, the patient has a good prognosis for regaining the ability to walk. If it does not, no statement can be made about prognosis (S. Horenstein, *personal communication*, 1988).

TABLE **26.7** *Synkinesias*

Babinski rising synkinesia	Flexion of the paretic thigh associated with flexion of the trunk (Fig. 26-18)
Leaning backward synkinesia	Extension of paretic legs associated with extension of trunk (Fig. 26-19)
Néri sign	Knee flexion of paretic leg associated with flexion of trunk in standing position (Fig. 26-20)
Triple flexion	Dorsiflexion of the foot in association with flexion of knee and hip of paretic limb
Souque test (interossei phenomenon)	Overextension and spreading of fingers associated with elevation of paretic arm
Klippel–Weil test	Flexion of the thumb in association with passive extension of the other fingers in paretic arm
Raimistes leg sign	Paretic limb carries out motion (adduction or abduction) that is forcibly prevented in the normal limb (Fig. 26-21)
Hoover test	Normal heel presses down on table as patient attempts to lift paretic leg

Tetanus

A sustained tonic spasm of the muscles, most notably in the jaw, where it is called *trismi or lockjaw*, results *inter alia* from the toxin produced by *Clostridium tetani*. Such spasm can be precipitated by almost any type of stimulus. Severe generalized muscle spasms, prominently involving the face, trunk, neck, and back, may cause facial grimacing (risus sardonicus), opisthotonos, and ventilatory compromise. Laryngospasm may also occur.

Tetany

Tetany is a disorder accompanied by intermittent tonic muscle contractions often accompanied by dysesthesias. Distal muscles are most prominently involved, with carpal and pedal spasm. It is usually caused by hypocalcemia but may also result from hypomagnesemia or severe alkalosis.

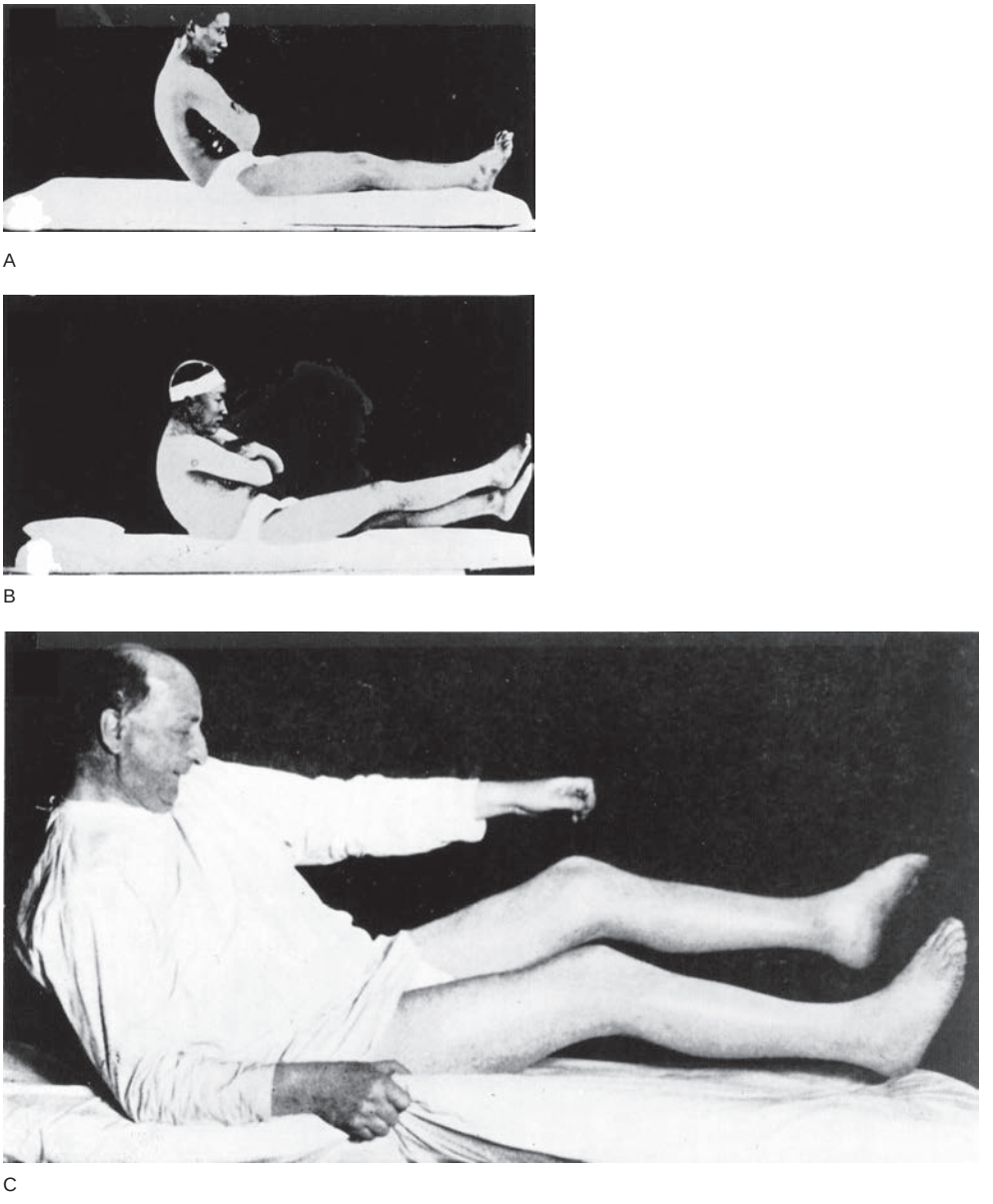


FIGURE 26-18 The Babinski rising synkinesia. **A:** Normal individual. **B:** Patient with spastic paraparesis of both legs, presumably due to a lesion of the leg area of the motor cortex caused by a gunshot wound at the vertex. **C:** Patient with a right frontostriatocallosal lesion, presumably due to occlusion of the right anterior cerebral artery. (From Alexander L. The neurologic examination. *Pullen's Medical Diagnosis*. Philadelphia, PA: W. B. Saunders; 1950, with permission.)

Of the many tetanic equivalent tests, I use only three: Trousseau test; a test whose name I do not know; and the Chvostek. Many more tests are described in DeJong (1979).

The Trousseau Sign

A Method

1. Place the blood pressure cuff around the biceps, and inflate the cuff well over systolic blood pressure. Observe the hand for an arbitrary minimum of 3 minutes, unless the test has already become positive.

   DeJong leaves the tourniquet on for up to 4 minutes; other authors leave the cuff on for 5 minutes. In the von Bonsdorff test, the tourniquet is left on for 10 minutes. Then it is removed and the patient is made to hyperventilate before the test is considered negative. One Chvostek-positive hypoparathyroid patient required 20 minutes of the tourniquet before the Trousseau test became positive (Simpson, 1952). In the original Trousseau test, there is no mention of how long the band must be left on the patient's arm before the test is considered negative. Similarly, the extent of blood pressure cuff inflation was never specified because in the original version of the test Trousseau simply gripped the arm and squeezed it with his hands (Trousseau, 1861).[13]

   Later Trousseau learned to use a constricting band when he observed a bloodletting at the Necker Hospital performed upon a woman with this sign. When the tourniquet (constricting band) was applied to her arm, the spasm appeared quickly. Only much later, after Trousseau's death, was the blood pressure cuff employed as the constricting band.

2. A positive test is shown when the tested hand involuntarily demonstrates the tetanic equivalent of flexing at the wrist and

[13] Oddly enough, this original Trousseau maneuver later reappeared as the Hochsinger phenomenon. (Hochsinger was an Austrian pediatrician who was not born until 1860.) One suspects that this may be another epiphenomenon of the Franco-Prussian War, akin to the Traube sign (see Chapter 17).

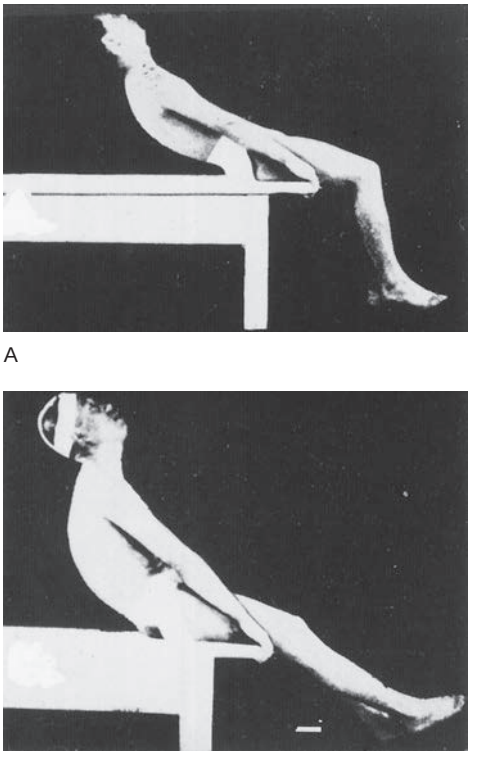


Figure 26-19 The leaning backward synkinesia. **A:** Normal individual. **B:** Patient with spastic paraparesis (same as in Fig. 26-18B). (From Alexander L. The neurologic examination. *Pullen's Medical Diagnosis.* Philadelphia, PA: W. B. Saunders; 1950, with permission.)

extending all the fingers. Trousseau referred to this as the *main d'accoucheur* (hand of the obstetrician). I personally avoid this name because it might be confused with the hand of the gynecologist, a term applied to the benediction hand (papal hand) of median nerve palsy (see Chapter 25).

Historic Note. Trousseau was one of those encyclopedic clinicians produced in 19th-century France. Once Trousseau made an incorrect diagnosis in a case in which a local dolt made the correct diagnosis. Recognizing that all diagnostic medicine is merely a clever playing of the odds, Trousseau is reputed to have said. "Even a broken clock gives the correct answer twice a day." In addition to his test for tetany, he also described Trousseau syndrome: migratory thrombophlebitis as a sign of internal malignancy, which he later found in himself (see Chapter 19). Nowadays, when I ask, "Who was Trousseau?" I am variously told that he was an oncologist, an endocrinologist, a neurologist, or a phlebologist, according to the situation in which his name has arisen. It was all the same Trousseau.

Interpretation. The Trousseau test has a sensitivity of 66% in hypocalcemia and a false-positive rate of 4% (Simpson, 1952). It has been reported as positive in a case of hysteria (Thomson et al., 1977); the muscle contractions seen in some cases of Addison disease may appear to produce a positive Trousseau sign (Archambeaud-Mouveroux et al., 1987; Bornstein et al., 1962). However, the case for a positive Trousseau sign in experimental hyponatremia is confounded (McCance, 1936) and the case for a positive Trousseau sign in nonalkalotic hypokalemia is unconvincing (Jacob et al., 1986).

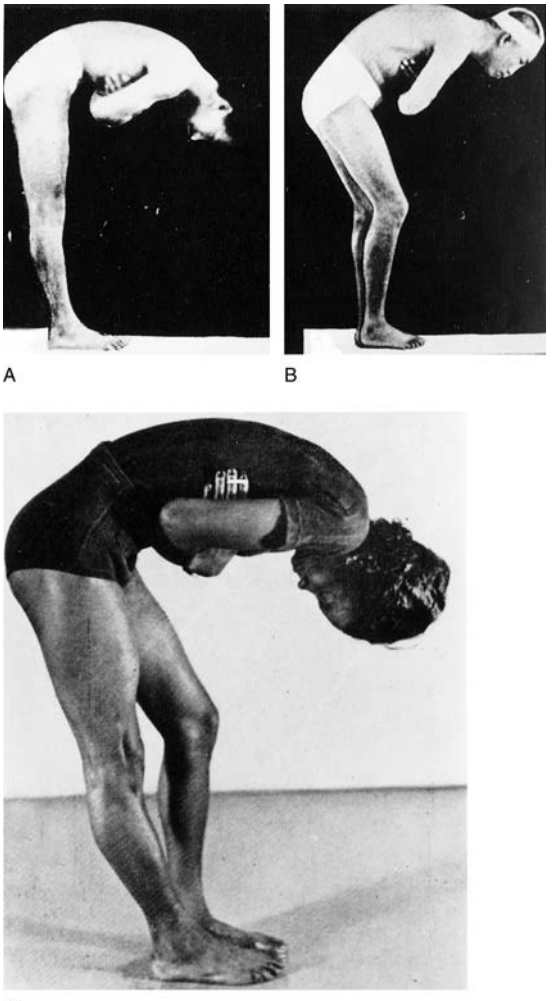


Figure 26-20 The Néri bending over synkinesia. **A:** Normal individual. **B:** Same patient as in Fig. 26-18B with spastic paraparesis. **C:** Flexion of the paretic left leg in a patient with a right front lesion. (From Alexander L. The neurologic examination. *Pullen's Medical Diagnosis.* Philadelphia, PA: W. B. Saunders, 1950, with permission.)

A Second Sign

A Method

An extremely valuable test for tetany is to tap *lightly* with the broad portion of the triangular-headed reflex hammer above the lateral malleolus. A tetanic equivalent is adduction, extension, and eversion.

This is the same response as is evoked in the Lust peroneal phenomenon. However, in the Lust phenomenon or sign, the stimulus is a tap at the lateral surface of the proximal fibula just below the knee, where the common peroneal nerve wraps around the lateral aspect of the fibula.

Significance. In my limited experience, this is one of the most sensitive of the tetanic equivalents. It is often the first to appear and, following treatment, the last to correct. However, nowadays it is impossible to gather good data on this test because of the rapidity with which house staff correct the various chemical etiologies of the tetanic equivalents.

The Chvostek Test

The Chvostek test is named in honor of the 19th-century Viennese clinician who described it.

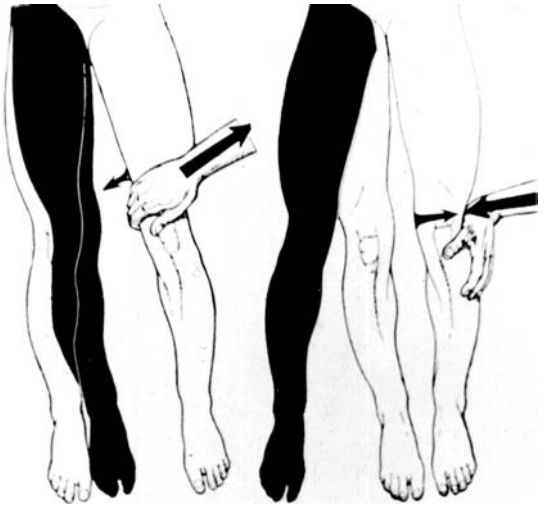


Figure 26-21 The Raimistes leg sign. Abnormal leg shown in black, normal in white. If the examiner opposes active adduction of the normal leg, the abnormal leg adducts. If the examiner opposes abduction of the normal leg, the abnormal leg abducts. In other words, the pyramidally paralyzed or paretic leg will carry out a movement identical with that which was forcefully prevented in the other normal leg. This maneuver brings out a latent tendency to symmetric homologous associated movements, following the same general rules as those of the arms. (From Alexander L. The neurologic examination. Pullen's Medical Diagnosis. Philadelphia, PA: W. B. Saunders; 1950, with permission.)

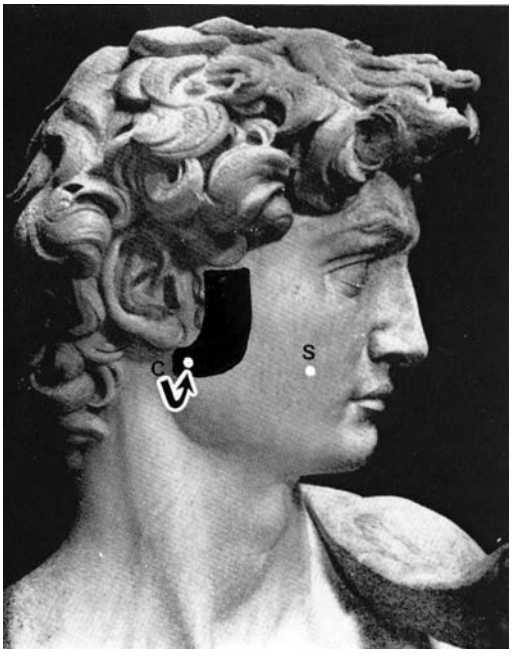


Figure 26-22 The indicated areas show the best places to search for the Chvostek "reflex," which is really not a reflex but rather a tetanic equivalent. Chvostek percussed the area marked "C," where the facial nerve is accessible in front of and below the external auditory meatus. Schultze preferred to percuss the region between the zygomatic arch and the corner of the mouth (marked "S"). One can also percuss at the "sideburn" area, marked in black (see text). (Detail from David, by Michelangelo.)

A Method

To perform the Chvostek test, tap the cranial nerve VII as it emerges *and* in the area of its first branches. Areas to be tapped are shown in Fig. 26-22. Use the reflex hammer for the points labeled "C" and "S." Percuss lightly with the tips of your fingers held together over the "sideburn" area.

A positive Chvostek test is obtained if tapping over this nerve causes a "reflex" contraction of some or all of the muscles it serves (muscles of facial expression.)

Interpretation. The Chvostek test has a sensitivity of 27% (Simpson, 1952) in latent tetany.

In addition to the tetanic conditions of hypocalcemia, hypomagnesemia, and alkalosis, the test can also be positive in disease of the pyramidal tract supplying the facial muscles. This is in essence a clonic reflex, whereas the true Chvostek sign of tetany is not a reflex but simply a sign of motor irritability. The Chvostek test is also positive in diphtheria, measles, smallpox, scarlet fever, pertussis, typhoid fever, tonsillar disease, tuberculosis, myxedema, "joint neuralgia," and "enteroptosis"[14] (Hoffman, 1958). Some of these may actually represent a fortuitous coincidence because of the high false-positive rates in normals.

The Chvostek test yields false positives in 19%, 20%, 30%, 40%, 45%, and 74% of variously reported series of normal children (Hoffman, 1958; Simpson, 1952). In adults, the comparable false positive rates are 4% (Dodelson, 1963), 5%, 16%, 25% (Hoffman, 1958), and 29% (Simpson, 1952).

A number of suggestions have been made for reducing the number of false positives:

1. Require the test to be positive bilaterally. (But the false positives were bilateral in 40%, 50%, and 80% of various series. Also, it is not known how many true positives are bilateral. A similar limitation in knowledge applies to many of the following techniques, any or all of which might also decrease the sensitivity of the test while trying to eliminate the false positives.)
2. Especially attend to percussion within the "sideburn area." In a series of false positives (Hoffman, 1958), the test was falsely positive at *both* the Chvostek and Schultze points (Fig. 26-22) in 71%, only at the Schultze point in 24%, and only at the Chvostek point in about 5%. Very few false positives seem to be produced by percussing lightly in the "sideburn" area.
3. Require that the corner of the eyes be involved in the contraction of the facial muscles.
4. Ignore the slight motions of the angle of the mouth (and sometimes the corner of the nostrils) that result from the tap itself rather than from an actual contraction.
5. Keep the masseter muscle tense. The other muscles can still respond to the tetanic stimulus. This would also help eliminate the problem of the appearance of motion from the impetus of the blow.
6. Require both of two taps, administered within seconds of each other, to be positive. In the case of false positives, the first response may be positive and the second negative (Hoffman, 1958).

[14] Enteroptosis (or visceroptosis) means "fallen viscera." It was a nondisease of medical progress. Doctors learned anatomy on recumbent cadavers and surgical patients, and thus later saw the same organs "fallen" (through the effects of gravity) when viewed fluoroscopically on erect patients. This nondisease has been eradicated by eliminating both fluoroscopy and the vigorous teaching of gross anatomy.

General Significance

These tests all have the same basic significance, although the Chvostek test has the special considerations noted above. In summary, all these tests may be positive in hypocalcemia, less frequently in situations where the measured amounts of calcium and magnesium are normal but their ionized (physiologically active) fractions are decreased by alkalosis (0.16 mg/dL of ionized calcium adjustment for every 0.1 pH unit), and *rarely* in hypomagnesemia uncomplicated by concurrent hypocalcemia (Kingston et al., 1986). (See the case report described below.)

Usually, the magnesium and pH are normal and the tetanic equivalent is the result of one of the classic causes of hypocalcemia: hypoparathyroidism, vitamin D deficiency, steatorrhea, or renal insufficiency. At other times, there are mixed etiologies, as when hypomagnesemia inhibits the normal release of parathormone from the parathyroid glands, causing a secondary hypocalcemia.

Case Report. A patient was admitted with a serum calcium level of 5.5 mg/dL, an albumin level of 2.5 g/dL, a serum magnesium level of 0.7 mEq/L (normal > 1.5), and an arterial pH of 7.60. Yet, he had no Chvostek, Trousseau, or lateral malleolus sign, on repeated testing by many. The significance of a serum potassium concentration of 2.3 mEq/L as a modifying factor was discounted because it was not sufficiently low to cause paralysis. Dr Gert Muehlheims was consulted and he pointed out that the hypokalemia was a "well-known" modifying factor in the production of tetanic equivalents, operating at the membrane, without the requirement that it be severe enough to paralyze.

The membrane equation states that the excitability of the neuromuscular unit is proportional to the ratio

[potassium][hydroxide]/[calcium][magnesium]

A high ratio leads to tetany, whereas a low one leads to weakness or paralysis.

This analysis is inadequate in a number of ways. First, the intracellular/extracellular ratios are not shown. Second, the extracellular concentrations have no precise mathematical relationship to each other. Third, the actions are misrepresented. For example, alkalosis acts through decreasing the ionized fraction of calcium not through a direct effect on the resting membrane.

Nevertheless, the utility of the above may be considered in light of subsequent events. The house staff, unimpressed by two antediluvian professors ranting about fluxes of ions across membranes, proceeded to do that which they do best—repletion therapies. The patient had difficulty elevating his magnesium levels, in part because the house staff was careful to go slow and low and avoid magnesium intoxication, and in part because his intracellular depletion was even greater than his serum depletion. The continued hypomagnesemia also inhibited his response to calcium repletion, probably through inhibiting the release of parathyroid hormone. His potassium repletion alone was briskly achieved. Then the nurses called the house staff to report the occurrence of a grand mal seizure, surely one of the more dramatic of the tetanic equivalents.

Reflexes

Thomas Willis, who is today remembered only for his circle, invented the word "reflex" in his 1664 text on the brain, illustrated by Sir Christopher Wren (Chassis and Goldring, 1965). (Willis also invented the word "voluntary" for striated muscle movement, adopting it from scholastic philosophy, thus explaining his unusual definition that such movements occurred by the will of the person, who therefore took full moral responsibility for them.)

Deep Tendon Reflexes

A Digression on Reflex Hammers

The first reflex hammers that were used were winemakers' hammers. These had already been adopted for percussion of the chest, and in fact the use of the pleximeter for mediate percussion derived directly from the way that winemakers percussed barrels. Later it was realized that immediate percussion (see Chapter 16) was just as good, and only the little hammer was kept (for a while) for percussion. Later it was adapted for deep tendon reflexes.

The first hammer made specifically for the neurologic examination was the Taylor hammer, the rubber triangular-headed hammer, pictured in Fig. 26-24.

The Queen's Square hammer (Fig. 26-26) was first made as a gift by the head nurse in radiology for her beau, a neurologist, by sticking a radiator handle on a piece of Malaccan cane. Soon everyone wanted one. Because the Empire no longer provides Malaccan cane, they are now made of plastic.

General Observations on Reflexes

Note the strength and symmetry of the reflexes. A grading system is given in Table 26.8.

Alternately, if you tap *lightly* initially, gradually increasing the strength of your blow to the gentlest rap that will elicit a reflex, you can grade the reflex according to the degree of your own effort.

In children, the upper-extremity reflexes are normally stronger than the lower-extremity reflexes. In senescence, this is reversed (S. Horenstein, *personal communication*, 1988).

The examiner should train himself to sense slight asymmetry and delay in the reflexes indicating subtle interference with nerve conduction (Dorman and Ravin, 1991).

You may need to reinforce the reflex by various methods, especially the Jendrassik maneuver (*vide infra*).

TABLE **26.8** *Grading system for deep tendon reflexes*

Grade	Reflex
0	No contraction perceptible
1+	Contraction barely but definitely perceptible
2+	Contraction obviously perceptible; barely perceptible relaxation phase
3+	Vigorous contraction apparent from across the room
4+	Hyperactive contraction; most neurologists equate this with the presence of clonus, although some use "5+" to designate clonus

The Jaw Reflex (Masseter or Mandibular Reflex)

Standard Method

1. Place your finger over the top of the patient's chin, opening his jaw sufficiently to enable you to detect a reflex closing.
2. Hit your finger sufficiently hard to put a stretch on the masseter muscles. The masseters will contract.

Interpretation. The presence of the reflex implies that the trigeminal nerve's sensory and motor portions are intact on at least one side, as is the reflex center in the pons. This is the only deep tendon reflex innervated from above the foramen magnum.

This reflex is sometimes absent in normal people.

The jaw jerk provides the "normal" control for the patient with spinal cord disease, when you are trying to find the level of disease and want to know whether a lower reflex is hypo- or hyperactive. As a general rule, the jaw jerk is the same strength as the biceps and the knee jerks, whereas the triceps seem to equal the ankle jerks (S. Horenstein, *personal communication*, 1988). The jaw jerk will be lost or diminished ipsilateral to a trigeminal (pontine) nucleus lesion but will be hyperactive with supranuclear palsies or pyramidal tract disease.

The Scapulohumeral Reflex

Strike the acromion or the spine of the scapula in a caudad direction. A positive response is a clearly defined elevation of the scapula or abduction of the humerus. This signifies compression of upper motor neurons cranial to the C3 vertebral body, as in the cervical myelopathy associated with rheumatoid arthritis, syringobulbia/syringomyelia, or Klippel–Feil syndrome (Shimizu et al., 1993; Heyde et al., 2006).

The Biceps Reflex

A Method

1. Have the patient's arm flexed at the elbow in the range of 90 to 130 degrees. This can be done by grasping his elbow in your hand, supporting both the elbow and the forearm by resting them on your own forearm. In this way, the patient can be perfectly relaxed while the proper angle is maintained. Alternatively, if the patient is sitting, you could have him place the arm "palm up" in his lap or on the physician's desk as if to prepare for the blood pressure measurement.
2. Place your thumb on the patient's bicipital tendon in the antecubital fossa. This is easy to find because it is the only tendon crossing this space. If you have trouble finding the first one (when you are practicing on your partner), ask your partner to rotate his hand externally just a few centimeters. As soon as the motion is initiated, you will feel the bicipital tendon jump up against your thumb.
3. Push your thumb against the tendon, but leave some "slack" in it. (With all these stretch/tendon reflexes, there must be some slack. If the tendon is pressed too hard, the reflex may not be obtained even from a healthy person.)
4. Hit your thumb with the reflex hammer. The arm should flex at the elbow (Fig. 26-23).

FIGURE **26-23** The biceps reflex (see text).

Interpretation. The afferent limb of this reflex is the musculocutaneous nerve; the efferent limb comes from segments C-5 and C-6, primarily the latter. If tapping the biceps tendon causes a contraction of the finger flexors, one must suspect an upper motor neuron lesion. With the so-called inverted biceps reflex, the biceps does not contract at all, but tapping its tendon smartly causes a contraction of the triceps and hence an extension at the elbow. This is thought to result from the unopposed response of the triceps as a slight lengthening of its tendon is sensed. The sign is said to be pathognomonic for a C-5–C-6 disc herniation with a C-6 radiculopathy (M. Schlitt, *personal communication*, 1999).

A Caveat. Of course, the afferent and efferent for all reflexes meet in the same segment at the internuncial neuron, and they travel in the same peripheral nerve trunk. *As a teaching convention*, we will name the segment as the efferent and the peripheral nerve as the afferent.

Remember the biologic variability observed in freshman anatomy class. All of these listings of neuroanatomic segments are written in protoplasm, not stone. They are probably only 99% accurate in actual practice.

The Triceps Reflex

A Method

1. Lift the *upper* arm (the brachium) so that the humerus is approximately parallel to the floor. The radius and ulna (the antebrachium), being unsupported, will hang down at approximately a 90-degree angle.
2. Hit the triceps tendon as it runs along the humerus, 2 or 3 in. proximal to the olecranon process of the ulna. (Do not hit the ulna itself because there will be no reflex unless the patient is a physician, in which case he will simply shake his head in wonderment at the new curriculum. But that is not the reflex you are trying to elicit.)
3. A positive reflex consists in the extension of the arm at the elbow.

A Caveat. With an overly cooperative patient, who postures the arm (thereby abolishing the reflex) out of a wish to help you, it may be necessary to say, "Let me do all the work, now" and to wiggle the elbow joint through about 30 degrees of extension and flexion.

Another trick to help the patient relax is to have him place his hand upon his hip.

Interpretation. The afferent limb is the radial nerve and the efferent limb comes from spinal cord segments C-6 through T-1.

This is an excellent reflex to test for C-7 nerve root compression syndrome (C-7 radiculopathy).

Reinforcement. Teeth clenching is a proven Jendrassik maneuver (*vide infra*) for the triceps reflex (Tarkka and Hayes, 1983) as is contraction of the lower-extremity muscle (Delwaide and Toulouse, 1981). The amplitude of the reflex may also be increased by having the patient turn his head toward the side being tested; this maneuver will also shorten the latency time. Turning the head away from the side being examined has the opposite effect (Tarkka and Hayes, 1983).

The Brachioradialis Reflex

A Method

1. Place the forearm so that the radial surface is superior. If the patient is sitting, he may rest the forearm across his thigh or place his arm on the physician's desk. In other circumstances (as with the bed-bound, frail patient), the physician may simply lift the arm into position by holding the patient's hand or by holding the forearm from beneath.
2. Strike the radial surface at the junction of the middle and distal third of the radius.
3. A positive response is extension at the wrist and inversion (medial rotation of the radial hand).

Interpretation. The afferent limb is in the radial nerve and the efferent limb comes out of spinal cord segments C-5 to C-8, mostly C-6 and C-7.

If the brachioradialis reflex gives finger flexion as a response, without the other motor activities (an "inverted" reflex), and the finger flexion is spastic, this indicates a segmental transverse spinal cord lesion at the level of the missing muscle response. The descending intraspinal sublesional fibers cause the fingers to respond, but they are disconnected from the inhibitory pathways of the higher centers by the segmental lesion and hence their response is spastic. The "inverted" reflex results from the combination of an upper motor neuron lesion (the spastic finger jerk) and a lower motor neuron lesion (the absent brachioradialis response). This is a general rule of reflexes that is less often noted at the biceps and triceps jerks.

The Thumb Reflex

The thumb reflex is altered in disease of C-7 or in five of seven cases of entrapment neuropathy of the anterior interosseus nerve (Kiloh–Nevin syndrome) (Rask, 1979).

A Method

1. After assuring yourself that the brachioradialis reflex is intact, grasp the patient's hand with your non–hammer-wielding hand and supinate the patient's hand. Then extend (dorsiflex) it at the wrist to about 45 degrees by exerting pressure on the palm with your grasping hand. But do not touch the patient's thumb (because thumb flexion is the anticipated response).
2. Find the tendon of the flexor pollicis longus (Fig. 26-24). One way is to have the patient alternately flex and extend his thumb while you press down on the volar surface of the radius, trying to feel the wiggling. (If the patient's thumb is paralyzed, you may have to do the same maneuver on yourself and transpose the information to the patient.) A good place to start your search is a thumb-length proximal to the navicular tuberosity on the volar aspect of the patient's wrist. (Try it on yourself, now.)
3. Hit the tendon and watch the thumb flex at the distal interphalangeal joint.

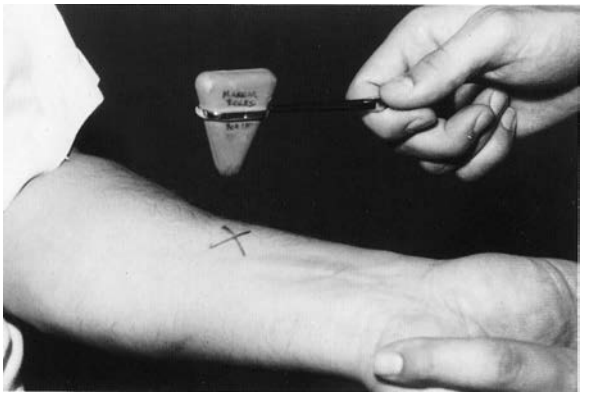


Figure 26-24 The thumb reflex. In this subject, the tendon of the flexor pollicis longus, shown as an "x," is more proximal than indicated by the text, reemphasizing the importance of searching for this tendon in the individual patient.

Hint. Sometimes you have to reinforce the reflex. This can be done by asking the patient to clench and unclench his teeth or to push his feet together.

The Finger Flexion Reflex

This reflex gives information about segment C-8.

A Method

1. Place your fingers over the volar surface of the patient's fingers, which are held together and slightly curved.
2. Strike your own fingers, which extends the patient's fingers somewhat and activates the stretch reflex.
3. A normal response is flexion of the fingers (Fig. 26-25).

Figure 26-25 The finger flexor reflex. The arrow marks one place where the hammer could strike. Actually, a blow to any of the examiner's fingers would stretch the patient's fingers and thus elicit the reflex.

The Pronator Reflex

The afferent fibers for this reflex are carried in the median nerve and the efferent fibers come from spinal cord segments C-6 through T-1.

A Method

1. Lift the patient's forearm straight up by holding onto the patient's fingertips, with the patient's elbow resting on the bed, examining table, or other stationary object. Do not hold the fingers too tightly because the normal reflex response will be pronation of the forearm.
2. Hit the ulnar surface and watch for hand pronation.

Modifications. DeJong elicits the response with the patient's forearm in semiflexion and the wrist in semipronation, but I favor the starting position of DeGowin, given above. One may also hit the radial surface and get the same pronation response. (Try it on your partner or yourself.)

The Pectoral Reflex

A Method

1. Rest the patient's arm and forearm so that the humerus is abducted about 30 degrees out from vertical zero.
2. As with the biceps reflex, you will not strike the tendon directly, but rather through the intermediary of your thumb or forefinger. So, place your mediate thumb or forefinger in the front of the axilla where it joins the anterior body wall. That little "curtain" that separates the axilla from the anterior chest is the insertion of the pectoralis major muscle on the greater tubercle of the humerus.
3. Strike your digit (with the hammer coming from below), and you will feel rather than see the contraction of the muscle, accompanied by internal rotation and adduction of the humerus.

Significance. This reflex tests spinal cord segments C-5 through T-1. Can you see why a clinician might go a lifetime and never check this reflex? The reason is that it basically checks the same spinal cord segments as the triceps reflex plus the biceps reflex or the brachioradialis reflex. It is even more difficult to elicit than the triceps reflex. (All C-7 reflexes tend to be difficult to elicit—M. Schlitt, *personal communication*, 1999.) In fact, its only use is to check those segments in someone in whom the other reflexes cannot be checked (i.e., someone with an above-the-elbow amputation). Its other reputed use—detecting a lesion of the anterior thoracic nerve—is more simply and specifically achieved by having the patient push down with his hands on his own anterior iliac spines. The little "curtain" representing the insertion of the pectoralis major will be missing on the side of the lesion.

The Hoffmann Sign

A Method

1. Extend and pronate the patient's wrist.
2. Let all the fingers except the middle finger fall into flexion.
3. Hold the terminal phalanx between your thumb and index finger.
4. Sharply flick the fingernail with your thumb, then release.

Interpretation. A positive response is adduction and flexion of the thumb and flexion of all the fingers as if to form a fist. It is said to be an index of motor hypertonia. There are both false positives and false negatives for corticospinal tract disease (Brain and Walton, 1969).

Knee Jerks (Patellar Tendon Reflexes)

A Method

1. Have the patient sit so that the leg to be examined is flexed but hanging in a free-swinging condition. This can be done by having the patient sit on the edge of the bed, which is raised to a sufficient height so that the patient's feet do not rest on the floor. If the patient is sitting in a chair, the legs can be crossed (with first one and then the other on top) and the upper one examined.
2. Find the patella and just below it the inferior patellar tendon, which inserts on the anterior superior surface of the tibia (Fig. 26-26).
3. Give the tendon a sharp tap.

Some neurologists check this reflex with the feet flat on the floor. However, it should not be done with just a *part* of the foot touching the floor because the patient may tense the limb.

A Method for the Bed-Bound Patient. One method is to strike the superior edge of the patella. This can be done with the legs extended; the patella moves superiorly.

For the Attending. The following technique, which involves the customary infrapatellar tendon as the object of the hammer blow, is preferred for purposes of group demonstration: If you are right-handed, stand at the supine patient's right. Slip your left hand under the patient's right knee and lift it from the bed to produce sufficient passive flexion to elicit the reflex. Tell the patient to let you support the entire weight of his leg. Tap the tendon with the hammer in your right hand. Elicit the left knee jerk in the same manner.

Significance. The knee jerk tests spinal cord segments L-2 to L-4.

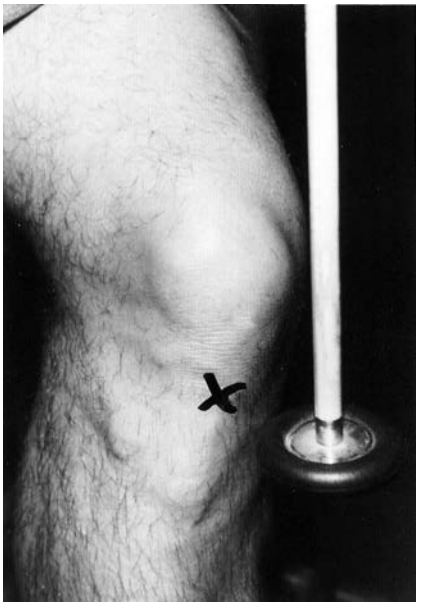


Figure 26-26 The knee jerk. "X" marks the spot. Any lower and you will be beating upon the tibia. Much higher, and you will hit the patella.

In the 19th century, several large series demonstrated an absence of knee jerks in 0.04% to 4.8% of healthy subjects. Jendrassik (1885) studied 1,000 controls "of various ages" and found the knee jerks missing in 1.6% of these. Of these 16 subjects, one had diabetes mellitus, which was already known as a cause of missing knee jerks; and in the other 15, the "missing" knee jerks could be "restored" by using the Jendrassik maneuver (*vide infra*).

No reflexes should ever be described as "absent" unless Jendrassik maneuver has been done.

Inverted Knee Jerks. If you strike the patellar tendon and the knee flexes (instead of extending), the patient has an "inverted" knee jerk. This is evidence of a spinal cord lesion at L-2, L-3, and/or L-4 (Boyle et al., 1979), which is almost always a transverse spinal cord lesion.

The Jendrassik Maneuver

Jendrassik first described voluntary contraction of the upper extremities so as to facilitate remote deep tendon reflexes, specifically the knee jerks (Jendrassik, 1883, 1885). This method may be applied to any recalcitrant reflex, including the ankle jerks.

Jendrassik maneuver is sometimes called "reinforcement" or "distraction," but after a century of study we still do not know the exact mechanism or mechanisms (Hayes, 1972).

A Method

1. Say to the patient, "Grab your wrists tightly and when I say 'pull,' try to pull them apart." Demonstrate this for the patient yourself.
2. When you are positioned to elicit the reflex, say "Ready, …1…2…3… pull!" At the last word, rap the patellar tendon.

Some Observations. A few empiric observations that have been scientifically studied are worth noting:

1. Having the patient turn his head toward the side being tested will facilitate the facilitation (Tarkka and Hayes, 1983).
2. The louder the signal ("pull"), the greater the facilitation (Scheirs and Brunia, 1982).
3. The amount of facilitation is directly proportional to the intensity of the maneuver. If at first unsuccessful, be sure that the patient is exerting maximal effort on the voluntary contraction of the remote muscles (Hayes, 1972).
4. The facilitation only lasts from 1 to 6 seconds after initiation of the voluntary contraction (Hayes, 1972) and is maximum for only 300 milliseconds (Kawamura and Watanabe, 1975), so be expeditious.

False Positives. There are three kinds of neurologically intact patients in whom an unmodified Jendrassik maneuver does not work (i.e., the finding of "absent reflex despite Jendrassik maneuver" is a false positive). The first of these is the tense patient who responds to the instruction "pull" by tensing all the voluntary muscles, not just the ones remote from the area where you are trying to elicit the reflex. This effectively suppresses the deep tendon reflexes. The second group includes the tense people I call "anticipators." They are like linemen in football who go offside by anticipating the quarterback's cadence and so are moving before the signal. The third group comprises the 20% of classical ballet dancers (especially women who have been going "on point" for 8 to 10 years) who do not have knee jerks or ankle jerks (Goode and Van Hoven, 1982). Whether or not these are truly "false positives" is left to the wise discretion of the thoughtful reader. The reflexes are as truly absent in these patients as they are in those with neuropathy, myelopathy, radiculopathy, and so forth. On the other hand, these are neurologically healthy persons whose missing reflexes are discovered by a thorough clinician who has usually been consulted for some other reason.

Remedies. Neurophysiologic studies of facilitation (Kawamura and Watanabe, 1975) reveal that the facilitation begins after the instruction "pull" but 100 milliseconds before muscle contraction begins. Accordingly, to elicit the reflex in such total body contractors, you need to catch them in the 100 milliseconds *before* they respond to your instruction "pull." To do this, advance the timing of your blow, so that you are starting your swing as you begin to pronounce "pull," thus catching the patient before he can begin the muscle contraction. (As with most of medicine, one learned this empirically before a scientific explanation was available.) It may take a little practice to perfect your timing because different examiners have different speeds of striking and different response times of their own; but as is usually the case, once mastered, this invaluable skill will not be lost.

For the anticipators who contract before being asked to "pull," the maximum facilitatory period may have passed even before you have started your hammer motion.

Again, the solution is to advance the timing of the hammer blow still further. After the patient has gotten used to the "Ready …1…2…3… pull" cadence, just say "Ready …1…2…3…" and begin tapping for the reflex before "pull." You may start tapping on "3" or in some patients even on "2.75." (It may take some time to "catch" the individual patient.)

Other Methods of Aiding Relaxation

Simply having the patient change position may help to bring out a reluctant reflex. A general method of helping patients relax that is also applicable to other parts of the physical examination is to ask the patient to tense briefly the part in question. Relaxation must follow the tensing and sometimes will go beyond the baseline state.

The Adductor Reflex

A Method

Place your finger transversely about 5 cm above the medical femoral epicondyle, with the patient's thigh in slight abduction. A blow to your finger will cause thigh adduction. (Other stimulus points are given by DeJong [1979].)

Significance. This reflex is not customarily tested because it is often absent and also because it tests L-2 to L-4, segments that are more easily evaluated with the patellar reflex. However, the motor nerve for the patellar reflex is the femoral nerve, whereas the motor nerve for the adductor reflex is the obturator nerve, the latter being the one that is trapped in an obturator hernia (Young et al., 1988). This leads to an excellent test for strangulated obturator hernia—the *Hannington-Kiff sign* (Hannington-Kiff, 1980). It consists of an ipsilateral loss of the adductor reflex with intact patellar reflexes. In the presence of acute abdominal obstruction, the Hannington-Kiff sign makes the diagnosis of a strangulated obturator hernia.

The patient may also have referred pain just above the knee in the skin area served by the obturator nerve, in which case the Howship–Romberg sign is also said to be present (see Chapter 22).

Ankle Jerks (Achilles Reflex)

Methods

1. Have the patient sit comfortably with his feet dangling down and not touching the floor. After you gently dorsiflex the foot, rap the Achilles tendon (Fig. 26-27).
2. Alternately, have the patient sit comfortably in a chair with both feet planted on the floor. Tap the Achilles tendon and feel for contraction of the calf muscles with your other hand.

Recalcitrant Ankle Jerks. First, remember to wiggle the foot passively in the extension–flexion dimension (prior to placing it in dorsiflexion (extension) and striking the tendon with the hammer) so as to determine that the patient is not posturing his foot. Next, try the Jendrassik maneuver (see above), which can also be used with the special positions and manipulations described below.

If the patient is not bed-bound and "all else fails," some recommend that the patient be asked to kneel on a chair, with the upper extremities and thorax supported by the back of the chair, the abdomen and pelvic girdle supported on the knees, and the ankles hanging from the front edge of the chair. With the patient's weight so distributed, it is nearly impossible for him to posture the feet; thus, the ankle jerks can usually be elicited if present.

Some say the best method of all is to have the patient lie prone on the examining table with his feet projecting over the lower end of the table. Dorsiflex the foot slightly with one hand and tap on the Achilles tendon. Reinforcement is seldom necessary with this method (Dorman and Ravin, 1991).

If the patient is bed-bound, the physician should place the ankle to be tested lateral to the opposite shin by flexing the patient's knee and slightly rotating the hip externally. Here, the legs resemble a figure four: The vertical stroke is represented by the nontested leg, which supports the lateral surface of the leg being tested, permitting the ankle to be clear of the bed (Fig. 26-28). Alternately, one may be able to elicit the reflex simply by externally rotating the leg.

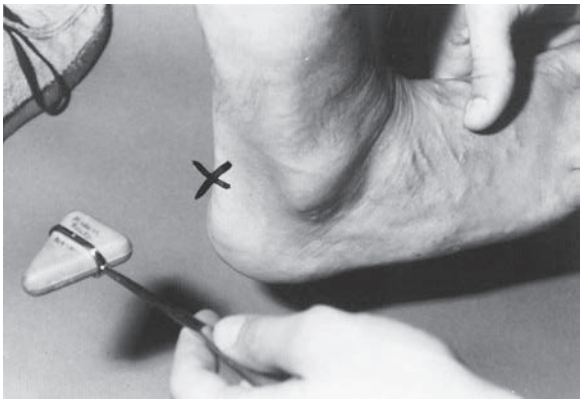


Figure 26-27 The Achilles reflex. According to legend, young Achilles was made almost impervious to harm when he was dipped in the magic river. However, because he was held by the heels, he remained vulnerable at that point—hence, the Achilles heel and tendon. The Achilles tendon reflex is vulnerable to disc herniations and other causes of S-1 nerve root impingement or damage. The examiner is using the broad edge of the rubber hammer and will strike the spot marked "x."

Another possibility in the bed-bound patient is to use *mediate percussion* as follows: Place your own finger over the plantar surface of the patient's passively dorsiflexed foot, as the patient lies supine, both legs comfortably resting side by side. Strike your own finger, thereby dorsiflexing the foot further and activating the tendon reflex.

A third method for the bed-bound patient is to have the patient "sit in a chair" while lying supine. Flex his hip to 90 degrees, flex his knee to 90 degrees, and hold your hand against his sole in place of the "floor." Then strike either the "floor" or the Achilles tendon.

Significance. The afferent limb of the reflex is the posterior tibial nerve; the efferent limb comes from segments L-5 to S-2, mostly S-1. *This is an excellent reflex to test for S-1 radiculopathy*.

In practice, absence of the ankle jerk is not very good for picking up root compression syndromes involving L-5. It is useful for root compression syndromes involving S-1, in which it is 85% sensitive with a "false-positive" rate of 10%. The latter figure refers to patients who have no myelographic evidence of disease such as a herniated disc, but many of these could actually be true positives for other diseases (Rico and Jonkman, 1982).

Ankle jerks are absent in 15% of all patients (Reinfrank et al., 1967). Most of these (78%) have diabetes mellitus, although only 32% of all diabetics are without ankle jerks (Abraham et al., 1966). The remainder will almost inevitably have a disease such as the ones listed in Table 26.9. Only 0.2% of patients under the age of 60 will have absent ankle jerks without such a cause.

This leaves the issue of how often the ankle jerks are missing in persons over the age of 60 for no reason other than age (or an unskilled examiner). A review of the figures in the reported literature for absent ankle jerks in the elderly gives a range of 27% to 50% of persons over age 65, 40% of those over age 75, and 38% to 80% of those over age 80 (Impallomeni et al., 1984), but these figures undoubtedly reflect improper technique. For instance, in a prospective study (Impallomeni et al., 1984), reflexes were elicited as follows: Patients were not examined until the day after admission (when they were more calm), and both mediate percussion and the Jendrassik maneuvers were used. Using this method, only 6% of all elderly patients (mean age 82 years) had missing ankle jerks, and

Figure 26-28 The figure-four position for examining the Achilles tendon reflex in the bed-bound patient. If the patient has difficulty getting his foot above the knee, it is permissible to have the foot recline instead on the shin, or to use a mediate blow as described in the text. (The Twilight by Michelangelo, from the tomb of Lorenzo de Medici.)

TABLE **26.9** *A few causes of missing ankle jerks (other than poor technique)*

Aging (see text)
Diabetes mellitus
S-1 radiculopathy, as caused by a herniated intervertebral disc at the L-5–S-1 interface
Tabes dorsalis
Eadie syndrome
Myotonic dystrophy
Ankle joint disease
Pernicious anemia
Systemic lupus erythematosus or other rheumatic diseases including rheumatoid arthritis
Severe myxedema
Alcoholic polyneuropathy
Amyloidosis
Spondylolisthesis with compression of nerve roots
Neuropathy of unknown etiology
Ballet dancers (see text)

most of these had a known explanation. *Only 1.5% of the patients studied had missing ankle jerks that had to be attributed to age.*

Speed of Contraction and Relaxation. The rapidity of contraction may be increased in some neurologic disorders as well as in hyperthyroidism.

The relaxation phase of the ankle jerk has been well studied. It is discernibly briefer than normal in 14% to 93% of patients with hyperthyroidism (Abraham et al., 1966; Rives et al., 1965) and immediately following exercise (Martin et al., 1970). It is diagnostically prolonged in 62% to 100% of patients with hypothyroidism (Abraham et al., 1966; Reinfrank et al., 1967; Rives et al., 1965) as well as in some other disorders (Table 26.10). (Of course, if the patient is known to have a neuropathy of the lower extremities only, there is no reason one could not estimate the deep tendon reflex relaxation time from a biceps tendon reflex.)

Using a recording device, the positive predictive value of fast reflexes (i.e., a shortened half-relaxation time) was found to be 92% for hyperthyroidism. The positive predictive value for prolonged relaxation time was 72% for hypothyroidism. The predictive value of normal reflexes was 99.3% for the euthyroid state (Reinfrank et al., 1967).

In a study that stratified patients by age, an Achilles reflex time (from tapping the tendon to muscle half-relaxation) less than 240 milliseconds had a true-positive rate of 37% and a false-positive rate of 0% for hyperthyroidism in patients aged 30 to 59 years. The true-positive rate was 48% and false-positive rate 0% in patients aged 60 to 83 (Nordyke et al., 1988).

Other Tricks

1. The prolonged ankle jerk of diabetic neuropathy (the Roberts sign) can sometimes be elicited after repetitive tapping of the ankle jerk, every 1 or 2 seconds, for at least six taps (Roberts, 1982). Sometimes the reflex could even be extinguished. These phenomena are not seen in myasthenia gravis or thyroid disease.
2. The absence of deep tendon reflexes has received adequate emphasis as a sign of Eaton–Lambert syndrome (the Doi sign). However, a peripheral neuropathy might be an alternate explanation.

TABLE **26.10** *Causes of prolonged Achilles tendon reflex*

Hypothyroidism
Neuropathic disorders
Neurosyphilis
Syringomyelia
Pernicious anemia
Diabetes mellitus
Sarcoid
Muscle disorders
Myotonia congenital
Other myotonic disorders
Local edema
Hypothermia
Drug therapy
Beta-blockers
Reserpine
Glucose infusion
Potassium infusion
Quinidine
Female sex (including pregnancy, ballet dancers, and anorexia nervosa)
Aging

From Abraham AS, Atkinson M, Roscoe B. Value of ankle-jerk liming in the assessment of thyroid function. *Br Med J.* 1966;1:830–833; Carel RS, Korezyn AD, Hochberg Y. Age and sex dependency of the Achilles tendon reflex. *Am J Med Sci.* 1979;278:57–63; Ingbar SH, Woeber KA. The thyroid gland. In: Williams RH, ed. *Textbook of Endocrinology.* 5th Ed. Philadelphia, PA: W. B. Saunders; 1974; Martin FIR, Chow E, Alford FP. Age and sex dependency of the Achilles tendon reflex. *Am J Med Sci.* 1970;1:759–763; Simpson GM, Blair JH, Nartowicz OR. Prolonged Achilles reflex in neurosyphilis simulating "myxedema reflex". *N Engl J Med.* 1963;268:89–91; and Zachmann M. Influence of glucose and insulin administration on the Achilles tendon reflex time. *Br Med J.* 1967;4:528–529, with permission.

In Eaton–Lambert syndrome, the reflexes may be made to reappear following a brief (10–second) period of maximal voluntary contraction (Doi et al., 1978). This will easily distinguish Eaton–Lambert syndrome from neuropathy, or for that matter from myasthenia gravis.

The Babinski Sign

Actually, there are several Babinski "reflexes," the first four of which are synkinesias (see earlier in this chapter).

First, the platysma muscle contracts on maximal opening of the mouth. Second, there is the Babinski rising reflex (Fig. 26-18) in patients with a lower-limb paresis. Third is the Babinski tonus test: the paretic arm cannot be bent to as acute an angle as the

normal arm. Fourth is the Babinski pronation sign: if both arms are abducted with the forearms supinated, and then suddenly released, the hemiparetic arm generally pronates while falling back toward the body while the normal arm remains supinated.

However, when most people speak of "the" Babinski sign, they are referring to one of the many eponymic tests based upon dorsiflexion of the big toe, possibly with fanning of the other toes, in response to a noxious stimulus applied to the lower extremity, which occurs in pyramidal (corticospinal) tract disease.

This sign is not a proprioceptive reflex, but a nociceptive response, and the response is hierarchical, not "all-or-none" like the proprioceptive stretch reflexes.

A Method

1. Grasp the patient's ankle with one hand.
2. Use a semisharp disposable object, such as the splinterless broken jagged edge from a tongue depressor or a wooden toothpick, and then stroke the sole of the foot, beginning at the calcaneus and proceeding up the *lateral* aspect and then across the metatarsal heads toward the big toe. Do not touch the toes.

(Much nonsense has been written about what sort of objects can and cannot be used to stroke the sole. Although the patient should not be injured, the whole point of the procedure is to produce a noxious stimulus.)

Interpretation. The normal response is brisk plantar flexion, often associated with dorsiflexion of the foot at the ankle. This is a spinal segmental response mediated by the first sacral segment of the cord and is akin to the abdominal reflexes (Brain and Walton, 1969).

However, one may *rarely* see a slow, *tonic* plantar flexion, which is a pathologic sign. It resembles the foot's equivalent of a frontal grasp reflex (*vide infra*).

In the patient with an "extensor plantar response" or "positive Babinski sign," the big toe dorsiflexes. In a fully developed response, the other toes abduct or fan and the other joints of the leg flex. The Babinski reflex is part of the reflex flexion response of the spinal animal in response to a nociceptive stimulus. Confusion arises because the extensor hallucis longus, "misnamed by the anatomists," is really a flexor muscle in that its effect is to shorten the limb and it contracts reflexly in association with other flexor muscles (Brain and Walton, 1969).

The true-positive Babinski sign is said to be diagnostic of pyramidal tract disease (an upper motor neuron lesion in the corticospinal tract), as is sustained clonus.

True positives must be distinguished from false positives, in which there is rapid withdrawal flexion at the hip and knee, dorsiflexion of the foot, and sometimes dorsiflexion of all the toes, but no toe fanning. This false-positive toe dorsiflexion of withdrawal is abrupt, and it looks like a hand or foot being pulled back from a hot stove. In the true Babinski reflex, the movement is slower.

The false positive abrupt toe withdrawal from a noxious stimulus may also be produced by an adverse, but not completely unpleasant, sensation—the tickle. It has been said that the skilled neurologist can make the big toe extend or flex as he pleases, by using incorrect technique (Patten, 1996).

Unfortunately, there is a photograph of Babinski himself performing the Babinski reflex, and he appears to be stroking the ticklish part of the sole (Schoenberg and Schoenberg, 1977)!

It is believed that some false positives, especially those resulting from withdrawal, may be abolished by moving the hand at the ankle to exert pressure on the ball of the foot at the big toe. Others suggest warning patients that the test is unpleasant and likely to tickle, and that they should try very hard not to withdraw their foot. Thus fortified, most patients are able to hold their foot quite still and help the examiner make an accurate assessment (M. Schlitt, *personal communication*, 1999).

In perfectly alert patients, false positives may be seen following physical exhaustion, during the apneic phase of Cheyne–Stokes respiration, and when the short toe flexors are paralyzed. Some patients with athetosis and chorea are erroneously thought to have Babinski signs simply because their hyperactivity results in a coincidental extension following the stimulus.

Other false positives are seen in a variety of unconscious states. After the patient is aroused, the Babinski reflex can no longer be found. Scopolamine and barbiturates probably produce their false positives (when they occur) in a similar way. The extensor plantar response is normal during the first year of life.

False negatives occur from time to time in patients with other long-tract signs such as clonus (*vide infra*) and hyperreflexia. The reason for this is not known, although concurrent disease of the spinal cord from L-4 to S-2 will of course obliterate any response including a positive one. In chronic paraplegia, a pressure palsy of the peroneal nerve abolishes the extensor plantar reflex (Brain and Walton, 1969). Sometimes the Babinski can be made to disappear with an injection of physostigmine (DeJong, 1979). It is important to look for the response carefully on the first or second trial, as it fatigues rapidly (M. Schlitt, *personal communication*, 1999).

A positive Babinski reflex is found together with absent reflexes in combined systems disease secondary to vitamin B_{12} deficiency; the reflexes are abolished by the peripheral nerve damage.

Patten states that it is safest to regard the Babinski sign as the "ESR (erythrocyte sedimentation rate) of the nervous system." If truly extensor, it indicates a problem; but if flexor, it does not necessarily mean that all is well (Patten, 1996).

Equivalents

A large number of other stimuli have produced eponymic reflexes, with the same type of positive response.

The Oppenheim test requires a noxious stimulus to be applied to the anterior tibial periosteum, beginning near the knee and moving caudally. Scrape with two knuckles. This test is recommended when there is distal sensory impairment.

In the Gordon test, one simply squeezes the calves (more vigorously than when checking for thrombophlebitis) and observes for toe changes.

The Stransky test is performed by slowly and vigorously abducting the little toe, maintaining it in maximal abduction for 1 to 2 seconds, and then suddenly letting go. Dorsiflexion of the big toe occurs either while the little toe is abducted or immediately after it is released.

The Chaddock test is closest to the Babinski sign in that the noxious stimulus is applied to the foot, slowly stroking, but this time going around the back of the lateral malleolus and then across the lateral dorsum of the foot.

A Historic Note. In his time it was said that the best neurologist in St Louis was C. G. Chaddock; and the second best was

C. G. Chaddock, drunk. The number of observations that prompted this encomium may be deduced from the following story:

One day a St Louis University medical student stopped in Frank John's bar (known as Frank's) for a tipple and found himself standing next to Chaddock. The student became flustered, saying, "Gosh, I'm sorry, Professor Chaddock. I'm not supposed to be here. I'm actually supposed to be attending a neurology lecture."

"Don't worry, son," said Chaddock, "I'm supposed to be giving it."

In addition to the foot extensor response, persons with a positive Babinski also have motor activity at the hip and ankle that can usually be palpated better than seen. This becomes important in patients who have had their toes amputated but who may thus still be examined for a long-tract sign. Thus, the Brissaud reflex is a contraction of the tensor fascia lata upon stimulation of the sole of the foot.

It may be asked what one is to do if the entire foot has been amputated. As with Gordon and Oppenheim reflexes, the afferent area may sometimes involve an area beyond the sole; thus one is encouraged to apply a noxious stimulus over a wide area.

In summary, the Babinski, Oppenheim, and Gordon reflexes have served well. Probably any three of this cornucopia would be sufficient.

Plantar Flexion Equivalents

There are several tests named after Rossolimo that produce plantar flexion in cases of pyramidal system lesions. One involves hitting the ball of the foot at the point of articulation with the metatarsal bones, and another involves a quick snapping with the examiner's fingers applied to the tips of the small toes. Yet another plantar equivalent is the Mendel–Bechterew sign, which involves hitting the cuboid bone with the reflex hammer.

These plantar flexion signs are tonic foot responses, which include plantar flexion, toe flexion, and inversion. Thus, they are pedal equivalents of the grasp reflex (*vide infra*).

Because of the tendency to confuse students, I perform none of these plantar flexion signs. Wartenberg (cited by Alexander in *Pullen's Medical Diagnosis;* see Chapter 29) points out that other plantar flexion stretch reflexes include those by Yoshimura, Boveri, Villaret, Faure-Beaulieu, Kempner, Foerster, Weingrow, Zhukowski, Kornilow, Sicard and Cantaloube, and Markow, as well as the alternate reflexes of Bechterew, Yoshimura, and Rossolimo. There was even a Guillain–Barré reflex described in 1916 by authors better known for another entity.

(If one wished to catalogue in a similar fashion all the dorsiflexion reflexes, one could undoubtedly produce a longer list. For that matter, given the large number of sensory end organs located in the lower extremity, there is no reason an enterprising young physician could not invent his own reflex and name it after himself. In fact, I encourage the reader to do this.)

Fortuitous Variants

1. When the Babinski reflex results from interruption of the pyramidal tract within the spinal column, it is possible for the afferent arc to involve the area all the way up to the level of the lesion. This is called "an increased reflexogenic zone." In fact, there are even several situations in which the afferent arc is on the opposite side from the upgoing toe. For example, one might stimulate the right foot and observe the classic Babinski response on the left. This is called a *crossed Babinski reflex*; and like the crossed extensor reflex (*vide infra*), it is seen in bilateral (albeit incomplete) spinal cord lesions, bilateral intraspinal pyramidal tract disease, and bilateral cortical lesions.
2. Sometimes plantar flexion responses are followed by extension. Such reflexes are known as "biphasic pyramidal tract signs." They too indicate involvement at the spinal cord level, especially in the thoracic cord.
3. The *direct extensor thrust* is an extension of the entire limb in response to the physician pressing up against the sole. It is sometimes followed by plantar flexion or stepping movements. It is supposedly not seen in complete lesions of the spinal cord.
4. *The crossed extensor reflex* occurs when any kind of stimulation of the lower extremity causes ipsilateral withdrawal and contralateral extension. It is seen in severe spinal cord diseases other than unilateral pyramidal tract disease. This is also known as the Phillipson reflex; and given the opportunity for confusion, this is one place in which the eponym might be more useful than the operational description.

Clonus

Ankle Clonus

A Method

1. Grasp the patient's foot and rapidly put it through its entire range of extension and flexion three times in a row. On the last "wiggle," thrust it in full extension, pressing against the ball of the foot, and vigorously maintain it so. (This whole step should take only about 2 seconds.)
2. Clonus is present when there is rhythmic resistance to your maintained extension. (Rhythmic means that there must be at least three "beats" of clonus. Sometimes the clonus is sustained, and the foot will beat against the resistance for as long as you maintain it; sometimes, there are only three or four beats of clonus, each successively weaker than the last. Either of these is a positive sign. Feigned clonus is not rhythmic, or it continues during plantar flexion when the tendon is no longer stretched.)

Teaching Hint. Don't search for clonus until you have seen a patient with pyramidal tract disease. Elicit the sign in that patient. Once obtained, it is impossible to forget.

Significance. Sustained ankle clonus, usually occurring in tandem with a positive Babinski reflex, means spasticity from an upper motor neuron lesion, resulting in loss of inhibition of the muscle stretch reflex at the ankle. Two or three beats of clonus, however, can often be elicited from healthy young persons (M. Schlitt, *personal communication*, 1999). As noted above, other signs of pyramidal tract disease include increased muscle tone in response to passive movement, spastic paralysis, and hyperactive reflexes due to release of inhibition of the muscle stretch reflexes below the level of the lesion.

Clonus in Other Locations

Clonus can also be obtained from the quadriceps longus by grasping the patella, sharply pulling it downward, and maintaining the downward stretch. Alternately, one can strike the superior edge of the patella with a rubber reflex hammer, aiming the blow

downward (so as to stretch the tendon of the quadriceps longus); however, it is difficult to maintain stretch on the tendon with this maneuver, a problem some have solved by placing their finger over the patella, striking their finger with the hammer, and then maintaining pressure with the finger.

Jaw clonus is obtained by placing the examiner's finger on the patient's symphysis mentis (as for the jaw reflex), stretching the tendons either manually or with a hammer blow, and again maintaining the stretch pressure.

It is also possible to elicit clonus from the fingers and wrist by passively extending them and maintaining tension.

"Primitive" Reflexes

Primitive reflexes, normally present in infancy, may be seen in adult patients with dementia, frontal lobe lesions such as tumor or infarcts, or other lesions in the cerebral hemispheres or interrupting communication with higher cortical centers.

The Grasp Reflex

In adults, this is not a stretch or tendon reflex, but rather a contactual automatism, of which there are two types: positive, in which the patient attempts to maintain stimulus contact, and negative, in which he avoids the stimulus contact. The grasp reflex is of the first type. It is never present in normal adults. (In babies, the "grasp" reflex is actually performed as a tendon-stretching reflex.)

There are a variety of methods of testing, all of which have in common the stimulation of the palm of the hand and the response of finger flexion. One way to do this is to stroke with your fingers starting at the palm then out to the fingers and the distal (volar) surface of the fingers, just touching them. The positive response is the patient's fingers curling up to maintain contact. To avoid false positives, do not stretch tendons, and do *not* pull on the fingers. (The latter may elicit the thalamic traction response, another false positive.)

Sometimes, this is such a strong reflex that the flexed fingers of a comatose patient will hold the examiner's fingers (which had stroked the patient's palm in a distal direction) and permit the examiner to lift the patient's arm up from the bed as if the patient were cooperating. (This one version is mentioned to explain why families sometimes believe that comatose patients are responding to them by squeezing their hands.)

This pathologic reflex is based upon parietal lobe release, and so it can be found in any disease of the nervous system *except* parietal lobe disease. Although the grasp reflex has been championed as a frontal lobe sign, and it is true that frontal lobe is a common source of lesions that produce the sign, it is *not* diagnostic of lesions in this area.

As noted, the plantar flexion signs are the pedal equivalent of the grasp reflex.

The Snout and Sucking Reflex

A tap on or near the closed lips provokes a pouting movement in normal infants or demented adults. Likewise, contact of the lips with an object may cause sucking movements. In some patients, stroking the cheek with a finger or tongue blade may elicit a "rooting" response, a turning toward the stimulus. This is thought to suggest a greater loss of normal inhibiting responses than the snout or sucking reflex (Paulson, 1977). Take care not to confuse these reflexes with buccolingual dyskinesias.

The Palmomental Reflex

The palmomental or palm-chin reflex is a unilateral contraction of the mentalis muscle in response to a brisk stroke across the thenar eminence of the ipsilateral hand. It is said to be especially prominent in severely demented individuals, but also is reported in normals (Paulson, 1977).

An Avoidance Contactual Automatism

Gently stroke the ulnar side of the hand, going distally. In a positive response, the fingers or the whole hand may move away, and in some cases the whole arm may elevate.

This finding occurs only in parietal lobe disease; in fact, it is the only pure parietal lobe sign (S. Horenstein, *personal communication*, 1988). (Other parietal lobe signs are discussed later in this chapter.)

Cutaneous Reflexes

The Ciliospinal Reflex

This reflex is elicited by scratching the skin over the maxilla or by pinching the skin on the side of the neck, depending upon whether one wishes to check the afferent limb in cranial nerve V or in the cervical nerves. The efferent limb is pupillary dilatation mediated through the sympathetics.

The extent and time course of a positive (normal) response may be learned by going to the mirror and staring at the pupil ipsilateral to the cheek you scratch.

The Beevor Sign

This is a good sign for lower thoracic spinal cord injury.

Ask the supine patient to lift his head off the bed. Normally, the entire abdominal musculature will tense, and the umbilicus will remain stationary. However, in cord lesions at the T-10 segment or below, the umbilicus will be seen to ascend when the patient lifts his head, indicating paralysis of the lower abdominal musculature and unopposed action of the upper abdominals (M. Schlitt, *personal communication*, 1999).

Cutaneous (Superficial) Abdominal Reflexes

The stimulus for the upper abdominal cutaneous reflexes (right and left) consists of stroking with a noxious stimulus from above to below in a line about 2 in. beneath the costal border. The noxious stimulus can be the rough end of a fractured wooden tongue depressor.

The response is a contraction of the abdominal musculature, which pulls the umbilicus up and laterally toward the site you are stroking. This tests T-7 to T-9.

The middle abdominal cutaneous reflex consists of stroking from the side toward the umbilicus, exactly at the level of the umbilicus. Again, a normal response consists of abdominal muscular contraction moving the umbilicus toward the site of the stimulus. This tests T-9 to T-11.

The inferior abdominal reflex is elicited by stroking from below to above on a line parallel with the inguinal ligament but about 2 in. higher. Again, the umbilicus moves toward the stimulus. This is a test of T-11 to L-1.

The abdominal reflexes may be abolished with pyramidal tract as well as lower motor neuron lesions (M. Faria, *personal communication*, 1998).

Caveats

1. The test should be considered abnormal only if (a) asymmetric results are obtained (either right versus left, or above versus below the umbilicus) or (b) the response is missing bilaterally in one or two segments only. In other words, if all the responses are missing, the test is inconclusive.
2. If all the responses are missing, there may be an error in your technique. Optimally, the patient should be examined in a relaxed, supine position, with the stimulus applied at the end of expiration. Attend to the amount of pressures applied. Pressing too hard causes a defensive reaction, with voluntary contraction of all the muscles, thus eliminating the chance to see the segmental pulling of the umbilicus, which constitutes a positive response. Pressing too lightly will fail to elicit a response. The ideal stimulus is a wiping motion like that of a man shaving.

Cremasteric Reflex

Any noxious stimulus (such as stroking, light pinprick, or light pinching) is applied to the medial thigh. The normal response is homolateral contraction of the cremasteric muscle, with a gradual elevation of the testicle. This tests segments L-1 and L-2.

The Bulbocavernosus Reflex

If the dorsum and/or sides of the glans penis are subjected to a noxious stimulus such as a squeeze, the bulbocavernosus muscle contracts. This response may be palpated by placing a finger on the perineum right behind the scrotum. Additionally, there is contraction of the urethral constrictor (midline in the same area) and of the external anal sphincter (the "anal wink"). The latter is best detected by placing a gloved finger in the patient's anal canal. (However, the anal wink is also the less specific efferent limb of other reflexes involving the application of a noxious stimulus [*vide infra*].)

This reflex checks S-3 and S-4 and is especially useful in evaluating some of the neurologic causes of male impotence (see Chapter 3) or in checking for a cauda equina lesion.

The bulbocavernosus reflex may be checked in women by parting the labia and squeezing the clitoris. The efferent limb is sensed by feeling the bulbocavernosus muscle through the perineum.

The Anal Reflex (Anal Wink)

The external anal sphincter contracts in response to a variety of noxious stimuli (such as a pin scratch) nearby. I do not check it routinely, although it is popular among neurologists for checking the terminal spinal cord and cauda equina, among anesthesiologists for checking epidural anesthesia and other blocks, and among pediatricians because it is one of the normal newborn reflexes. It checks S-2 to S-5.

A Note

This list of reflexes is incomplete. As with the rest of the neurologic examination, a more detailed listing can be found in DeJong (1979).

Sensory Testing

An Overview

Formal sensory testing became part of the neurologic examination following advances in neuroscience as well as improved examination techniques. By the 1890s, it was recognized that pain and temperature sense were frequently impaired at the same time, and thus followed closely associated pathways. Brown-Sequard and Edinger verified the existence of a crossed afferent tract, the lateral spinothalamic tract. Although a "sixth sense" or proprioception was recognized by Bell in 1826, and impairments of proprioception in patients with tabes dorsalis suggested involvement of the posterior columns, the distinction between the two sensory pathways was not clear until 1898. In 1905, Rydel and Seiffer found that vibratory sense and position sense were closely related and that both were carried in the posterior columns (Freeman and Okun, 2002). These columns ascend in the spinal cord uncrossed to the nucleus gracilis and nucleus cuneatus in the medulla, and then fibers from the second neuron cross and ascend in the medial lemniscus.

Light touch sensation is carried in the anterior spinothalamic tract, but impulses concerning touch-pressure, kinesthesias (sense of movement), exact touch localization, and two-point discrimination are carried in the posterior columns. Vibratory sense is not a specific sensory modality, but rather a temporal modulation of tactile sense (Truex and Carpenter, 1969).

By 1955, the sensory examination included tests for light touch, superficial pain, deep pain, temperature, position, vibration, and two-point discrimination (Freeman and Okun, 2002).

Sensory examination is by its nature subjective. The patient's responses may vary over time even if one of the newer methods is used to deliver an identical stimulus each time. There are some tricks to uncover malingering; the ultimate proof of hypesthesia or anesthesia is a nerve conduction study.

Vibratory Sensation

Although it is not a separate sensory modality, vibratory sensation is still clinically useful. When tested in concordance with position sensation, it is a helpful assay of the human posterior columns. It can also be used to measure touch-pressure sensation.

There has been a great deal of discussion about which frequency tuning fork is truly the best. The 256-Hz fork has been recommended for testing vibratory sensation because it has the lowest vibratory threshold and greater sensitivity than the 128-Hz fork in pernicious anemia (Herbert, 1988). But the others have their champions. Dr Simon Horenstein of Missouri carries an *additional* 64-Hz fork because that is the frequency first lost by the Meissner's fibers. Some prefer the 128-Hz fork because the threshold is higher for this frequency than for 256 Hz (Plumb and Meigs, 1961); thus, a more difficult task is created. Additionally, the time for the vibrations to decay below the threshold of perceptibility, 15 to 20 seconds, is of quantitative use (Asbury, 1994). There are even those who like the 512-Hz fork on the grounds that one can save money by using the same tuning fork for testing both hearing and vibratory sensation, but this gives many false positives in older persons.

More important even than the frequency are the strength of the blow to the fork and the duration between the blow and the

application of the tuning fork to the patient. Young persons probably get more variable results than older examiners because the older examiners are more constant in their motions. (Also, as Jack Myers once said to a medical student, "The most important aspect of the neurologic examination is knowing which findings to ignore.")

A Method for Testing the Posterior Columns

1. If you have not already done so during the performance of the Weber test (Chapter 11), give the patient a reference sensation for vibration by placing the base of the vibrating tuning fork on his forehead or sternum. Ask the patient, "What do you feel?" He should say "buzzing," "tingling," "humming," or some other word that indicates that he feels vibrations, not simply the pressure of the base of the fork. If you must help the patient by asking, "Is it vibrating?" you should place the nonvibrating fork over the same area and ask if the patient can feel the difference. Then say, "It's just the first sensation that we're looking for. Pressure alone, like now, doesn't count. Okay?" Then wait to see if the patient indicates that he understands. In this manner, almost all patients can be taught to report vibration specifically and not just pressure. Another reference sensation can be elicited by placing the vibrating fork on the edge of the big toenail.
2. When the patient has indicated that he understands the instructions, say, "Now close your eyes. I will touch you, and you tell me if you feel the vibration (or vibration equivalent) or if you don't. I won't hurt you. Keep your eyes closed." Then strike the fork and place the base firmly against the bony prominence to be tested.
3. Say, "What do you feel?" (Don't say, "Is it vibrating?" or "Do you feel anything?") The patient should respond with one of the chosen words. If you are uncertain as to whether he is feeling the vibrations, ask, "Or are you just feeling the pressure?" You may have to hit the fork again because the intensity of the vibrations is constantly decreasing and an overly cooperative patient may wait until he can no longer feel vibration in order to give an affirmative response to the last question!
4. Additionally, if the patient can truly feel the vibrations, he should also be able to detect their sudden cessation. Accordingly, say to the patient, who has already said that he can feel the vibrations, "Keep your eyes closed and tell me the moment it stops." With your free hand, suddenly damp the tines. This sharp cutoff can easily be identified and is thus preferable to the more common practice of letting the tuning fork "run down on its own." When the latter happens, some overly cooperative patients spend a lot of time silently trying to decide if "it is all gone," while the frustrated examiner can clearly see that the tines are no longer moving.
5. Some overly cooperative patients also learn to pair the sound of the examiner striking the fork with the subsequent vibratory sensation. Control for this at least once by hitting the fork, silently damping it, and then applying it to an area previously determined to be normal. The patient should report pressure but no vibration.
6. Routinely, one should test one of the malleoli or the big toenail on both sides (M. Schlitt, *personal communication*, 1999). ("Routinely" means there is nothing in the history and nothing on the neurologic examination [including the position sense testing] to suggest neurologic disease.) Spending time on the thumbs routinely is less profitable. Herbert noted that the index toe lost vibratory sensation before the big toe in pernicious anemia (Herbert, 1988).
7. When testing the toes on a cold day, allow time for the patient's feet to warm up because cold increases the vibratory threshold and so may give a false positive for impaired vibratory sensation (Keighley, 1946).
8. If vibratory sense is impaired in the toes, sequentially test at the malleoli, the shins, the patellae, and so forth.

If diabetic neuropathy is suspected, one should also check vibratory sensation over the sacrum. Although the longest nerves in the body go to the toes, some diabetics actually have a myelopathy in addition to or without the peripheral neuropathy. Because the sacrum is the most convenient place to check the longest passage through the spinal cord, this examination improves the sensitivity of the neurologic examination as a screening test for complications of diabetes mellitus.

Validity

Each time the patient correctly identifies vibration versus pressure, or identifies the cessation of vibration on damping, it is considered a correct response. Seven correct responses with no incorrect responses is a highly reliable test for normal vibratory sensation. One incorrect response and eight or nine correct identifications is also a statistically valid test for normal vibratory sensation. But as the proportion of incorrect responses rises, the probability that the patient is guessing increases.

The statistical basis for the validity testing is called the *sign test* (Edwards, 1954), which is based on the binomial distribution. The question we are asking is whether the patient's responses are random. The probability of seven out of seven correct responses by chance alone is 0.0078. The probability of six or more correct out of seven (by chance alone) is 0.0625, which is greater than the 0.05 cutoff customarily used as a criterion for statistical significance.

Questionable Results

If the test results are questionable because of the manner of the patient's response, what should the examiner do? According to Susann's law, he should repeat the testing later. This law, named for a novel by popular author Jacqueline Susann, states that "Once Is Not Enough." It was taught to me by Dr Bruce McClain of Virginia.

Qualitative Testing for Nerve Injury or Compression

The "wrong" (vibrating) end of a 256-Hz tuning fork can be used in screening for nerve injury or compression neuropathy (Fig. 26-29). Early in the course of a compression neuropathy such as carpal tunnel syndrome, the patient will report greater sensitivity to the vibration, and later will perceive the vibration to be less strong than over unaffected areas (Mackinnon and Dellon, 1988). Dr A.L. Dellon of Baltimore uses the tuning fork to check sensation in injured children; they find the test to be amusing rather than frightening.

Remember that the tuning fork stimulates both sides of a digit. For the thumb, impaired vibratory sensation can be caused by a lesion in either the radial or median nerve, and in the big toe the problem can be in either the peroneal or the tibial nerve. Therefore, if you

Figure 26-29 The 256-Hz tuning fork is an excellent inexpensive tool to assess qualitative vibratory perception. The vibrating end of the fork is being applied to the pulp of the finger because the amplitude of vibration is greater. One wishes to be sure that failure to perceive the stimulus results from a nerve injury, not from a subthreshold stimulus. (From Mackinnon SE, Dellon AL. *Surgery of the Peripheral Nerve.* New York: Thieme Medical Publishers; 1988, with permission.)

suspect an entrapment neuropathy, you must ask "Is the vibration stronger on the top or bottom?" A peripheral neuropathy should have findings that are symmetrical right to left and top to bottom. Ask the patient: "Did those two feel different?" (Dellon, 1980).

Proprioception (Position Sense)

Proprioception is customarily tested in the lower extremities on a routine basis. Some physicians test the little toes in the belief that the longest nerve tracts in the body are best suited to a screening test. Others find the little toes clumsy to work with, and so test the big toe. Although the method is given for the big toe, the same principles apply to other toes as well as to the thumbs and fingers. The latter should be tested if one suspects a diagnosis affecting the upper extremities, such as syringomyelia, some diabetic Charcot joints, or myelopathy (in which a level must be determined).

A Method

1. The first trick is to position yourself so as to eliminate visual cues to the patient, or instruct the patient to close his eyes and glance up from time to time to see that he has done so. If the patient is bed-bound, and you are wearing a white coat, you can drape it over the patient's feet. (Alternately, use the bed sheet or a blanket.) It must be emphasized that many patients, especially those with decreased proprioception, will open their eyes in the middle of testing to see the position of their toes, no matter how clearly and pleasantly the examiner gives his instructions. This is not a reflection of the perverse nature of humankind, but an example of how anxious patients are to please. If unable to succeed at the task with his eyes closed, the patient may wish to help the doctor in his work by opening his eyes, thus being able to give the correct answer to the questions.
2. Tell the patient, "I am going to wiggle your toes. I want you to close your eyes so that you cannot see anything. I won't hurt you. Sometimes you may know where I have placed your toe, and sometimes you won't know. If you know, tell me where the toe is. If you don't know, tell me that you don't know."
3. Grasp the toe by its *lateral* edges. (If you grasp it by the top and bottom, many patients without proprioception can distinguish "up" from "down" by the relative pressure or position of the examiner's fingers, even when the examiner cannot tell that there has been a change.)
4. Wiggle the toe rapidly, alternating between the "up" and "down" position, then abruptly bring the toe to rest in an extended position. Announce to the patient that "this is 'up'." After some alternations, present the flexed position and identify it as "down."
5. Now wiggle the toe up and down and abruptly stop in one of the two positions, asking, "Where is it?" If there is a pause, be very careful to feel for movement. Some patients will wiggle their toe against your fingers in an attempt to get a clue to its position. If the patient does this, ask him not to, and repeat the trial.
6. If the patient wiggles his toe a second time, say, "I guess you can't tell without wiggling your toe." After two warnings, any toe wiggling should be considered an expression of inability to perceive the position of the toe, regardless of the correctness of the subsequent answer.
7. Present the "up" and "down" positions about an equal number of times, but not in a perfectly alternating manner.
8. If the patient announces "straight" when you are looking for an "up" or "down," find out what "straight" means. (Sometimes it is a hedge, and sometimes an "up.") If one cannot make a determination, throw out that trial and keep going.

After one has had some experience with this test, one can adopt a modification in which the overly cooperative patient is tested thus: wiggle the toe vigorously, thrust it into either the up or down position for just half a second and then wiggle it again, while asking the patient what position the toe *had* been in. Give him three answers to choose from: "up," "down," or "I'm not sure." The almost constant motion and the brief positioning keeps the patient from attempting to move his toe actively. Suggesting the third response legitimizes it for the patient who wishes to save face or please the doctor.

Validity

If the patient gets seven out of seven or eight out of nine correct, proprioception is intact. If fewer than this, either proprioception or reporting is impaired.

Where Does Position Sense Originate?

Medical students have long been taught that position sense originates from nerve endings in joint capsules. In animal studies, however, the nerve fibers that innervate the joints do not send neural impulses of any magnitude during the normal range of motion of that joint, but fire increasingly as the joint integrity is reached, that is, just before the ligament ruptures. In humans, joint position sense remains even after a total joint replacement is done. These observations suggest that proprioception, identifying the position of a joint in space, is most likely related to sensory input from the receptors in the skin overlying the joint. It has been demonstrated, for example, that when the skin of the hand is anesthetized with a local anesthetic, proprioception of the finger is lost, and that proprioception is correlated with the sensibility of the finger, as measured with two-point discrimination (Moberg, 1983).

Pressure Threshold and Innervation Density

These days, pressure threshold testing is more important for clinical decision making than vibratory testing.

Large myelinated sensory nerve fibers are of two types: slowly adapting and quickly adapting. The quickly adapting fibers transmit the neural impulses for movement perception and are divided into those for low frequency, mediated by the Meissner corpuscles, and those for high frequency, mediated by the Pacinian corpuscles. The slowly adapting fibers transmit information for the perception of constant touch and pressure. These impulses are mediated by the Merkel cell neurite complexes.

In contrast to a vibratory (wave form) stimulus, a constant touch stimulus is localized to the area of skin being tested. A stimulus applied to the thumb pulp is evaluating only the median nerve. This permits precise evaluations of the peripheral nerve for diagnosis of nerve compression, nerve injury, and nerve regeneration. The threshold for constant touch can be measured with a nylon monofilament (Fig 26-30). Filaments are sold in sets of 5 or 20, each one exerting a specific, repeatable force (Dellon, 1981), the $\log_{10}$ force ranging from 1.65 to 6.65 mg.

A Method for Determining Pressure Threshold with Semmes–Weinstein Monofilaments

1. Conduct testing in a quiet place after obtaining a careful history.
2. Give a demonstration before the actual testing, then shield the test area from view.
3. Instruct the patient to give a verbal response, like "touch," each time he perceives a touch.
4. Begin with the filament vertically above the test area and slowly descend until the filament is bowed. Do not allow the side of the filament to contact the skin. The filament should be bowed in about 1.5 seconds.
5. Maintain the bow for about 1.5 seconds, then slowly remove it, again in about 1.5 seconds. Avoid quick application and bouncing.
6. If a threshold is to be determined, start with a filament 2 to 4 units below the "norm" if available and progressively work up to several levels above the threshold. Then present the filaments in descending order and record the last one responded to.
7. Test comparable areas on both sides.

Interpretation. Ability to detect the filament with a log force of 2.83 demonstrates normal sensitivity to light touch and deep pressure. A threshold of 3.22 to 3.61 shows diminished light touch. A threshold of 3.84 to 4.31 shows absence of texture discrimination and diminished pressure sensation. A patient who cannot detect the 4.31 filament but can recognize the 6.65 has only rudimentary deep cutaneous pressure response. Thresholds on the sole of the foot are much higher.

One use of the filaments is to recognize small changes during rehabilitation. As it may take a year or more for nerve function to return, it may be of great psychological help to the patient to be

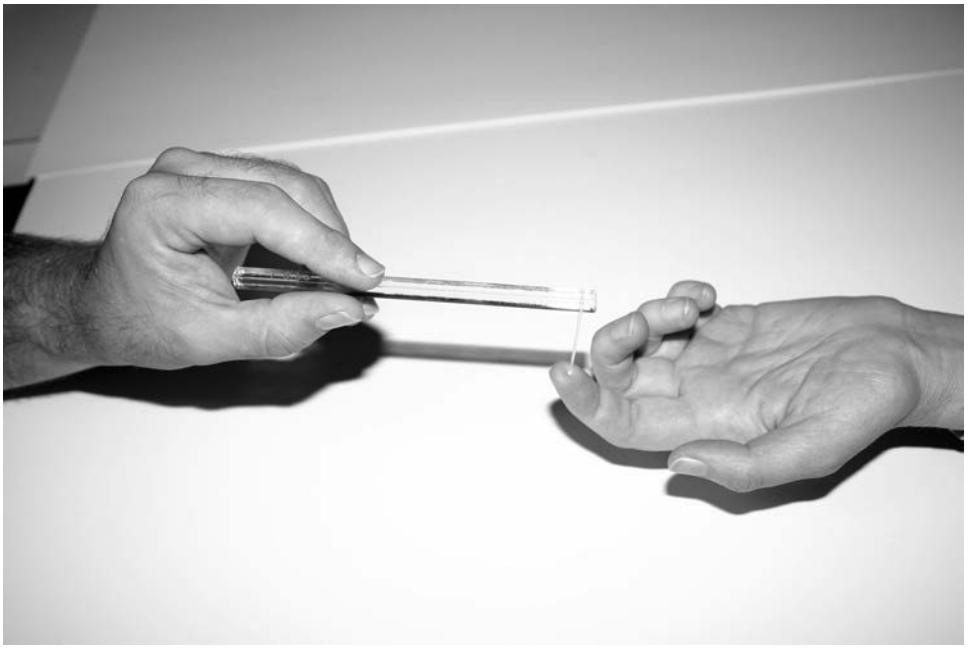


FIGURE **26-30** Testing sensory threshold with a Semmes–Weinstein monofilament. This particular fiber is too thick to bow when the proper pressure is applied; thus, it is less accurate than the more delicate fibers in the set.

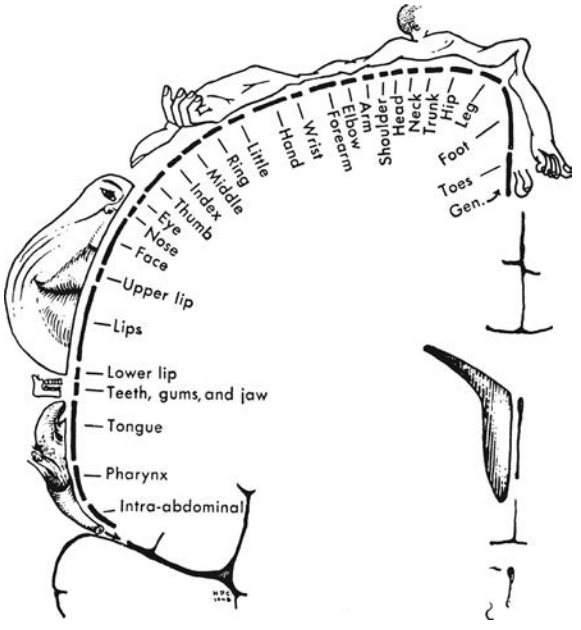


FIGURE 26-31 The sensory homunculus. (From Penfield W, Rasmussen T. *The Cerebral Cortex of Man.* New York: Macmillan; 1950, with permission.)

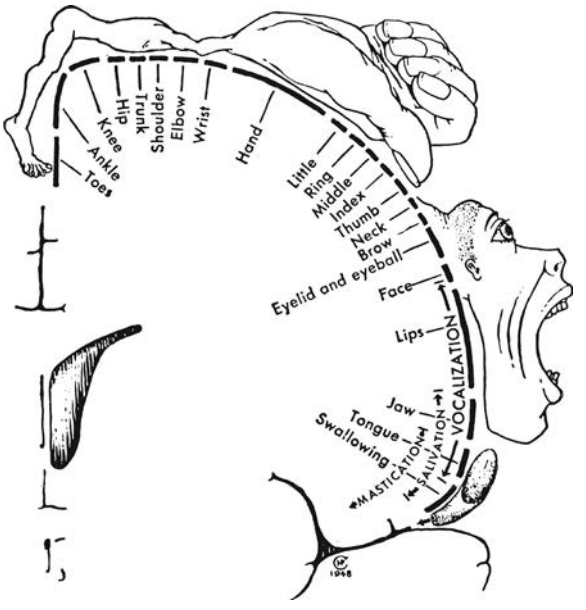


FIGURE 26-32 The motor homunculus. (From Penfield W, Rasmussen T. *The Cerebral Cortex of Man.* New York: Macmillan; 1950, with permission.)

able to measure changes that he has not yet discerned, as well as helping to guide therapy.

Innervation Density

The innervation density is the number of sensory endings per unit of skin. It is high in the fingertips and the tongue, as shown by the "homunculus" (Figs. 26-31 and 26-32). The threshold measurement for innervation density of the slowly adapting fibers is the static two-point discrimination, which is measured in distance (mm) between the two points. The threshold measurement for the quickly adapting fibers is the moving two-point discrimination, which is measured also in distance (mm) (Dellon, 1978).

Be aware that diminished two-point discrimination may also be caused by a parietal lobe stroke (*vide infra*).

Methods for Two-Point Discrimination

Using a compass, electrocardiogram (EKG) calipers, a bent paper clip, or a Disk-Criminator (Fig. 26-33), determine the minimum separation between the points at which the patient can determine whether he is being touched with one or two points. (If using a compass or calipers, be sure the points are not so sharp as to puncture the skin.) Always compare the two sides, using the healthy side as nature's own control. Where this is not possible, be aware that the normal distance varies greatly from person to person and on different parts of the body. The normal ranges are: fingertips, 3 to 8 mm; palm, 8 to 12 mm; back of the hand, 25 to 30 mm; chest, forearm, and shin, 40 mm; back, 40 to 70 mm; and thigh and arm, 60 to 70 mm (Wechsler, 1963). In the big toe, the normal range is reportedly 5 to 8 mm (Mackinnon and Dellon, 1988).

To test the quickly adapting fibers, move the two points quickly along the area to be tested in a proximal to distal direction. The perception of moving touch occurs before static touch during neural regeneration (Dellon, 1997). If using a bent paper clip, be careful not to stroke the skin with the barbed end. Begin with the points 5 to 8 mm apart and work down in stages to 2 mm apart. Move the points parallel to the long axis of the finger, and thus at an angle to most of the fingerprint ridges. Randomly alternate the testing stimulus to one or two points, and when the patient begins to answer slowly, or the threshold is being approached, require 7 out of 10 correct responses before proceeding to the next lower level. Thus, saying that the "m2PD (moving two-point discrimination) of the thumb is 2 mm" means that at least 7 out of 10 times, the patient correctly identified whether the stimulus moving down the thumb was one or two points (Dellon, 1978).

For specialized applications as in peripheral nerve surgery, a computer-linked Pressure-Specified Sensory Device (PSSD) (see Figs. 25-24 and 25-36) may be used. This has a force transducer attached to two hemispherical metal prongs that can be set a specified distance apart. The pressure threshold at which a one-point static stimulus can be distinguished from a two-point stimulus is the first variable to become abnormal in nerve compression syndromes (Dellon and Keller, 1997). Next, there is an increase in the distance required for two-point discrimination, and later a decrease in the pressure required to detect touch at one point (A.L. Dellon, *personal communication*, 2004).

Rationale for Testing: Is Diabetic Neuropathy Sometimes a Surgical Disease? If a patient has a decrease in two-point discrimination, this could be a sign of an entrapment neuropathy at a relatively early state when intervention is most likely to have a favorable result. Although diabetic neuropathy has been considered untreatable, except for exhortations to control the blood glucose more tightly in the hope of slowing progression, the potential contribution of entrapment syndromes is a rationale for surgical procedures, with reportedly good results (Mackinnon and Dellon, 1988).

On a purely theoretical basis, the "double crush syndrome" (later becoming the "multiple crush syndrome") was proposed in 1973. The hypothesis was that serial constraints on axoplasmic flow, each in itself insufficient to cause a nerve compression syndrome, could

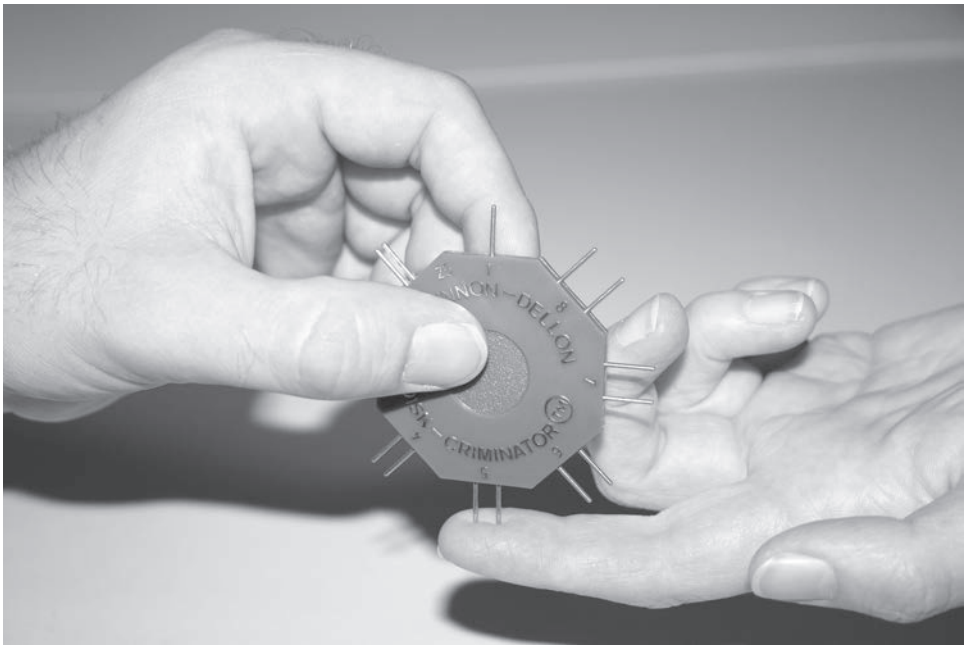


FIGURE 26-33 A Disk-Criminator, a device for testing moving and static two-point discrimination. The patient is asked whether she feels one or two points (see text).

summate to cause symptomatic neural dysfunction (Upton and McComas, 1973). The existence of the metabolic neuropathy had the same effect as one level of compression because of endoneurial edema.

Pinprick (Superficial Pain) Sensation

As the methods above provide a nonpainful means for checking integrity of sensory nerves, Dr A. Lee Dellon believes that a specific purpose is needed to justify inflicting pain. The method below is generally used as a quick and convenient way to check for intact sensation with materials readily at hand and is not very painful. There are situations, however, in which the integrity of the small unmyelinated nerve fibers that transmit impulses interpreted as painful, or of the lateral spinothalamic tracts, need to be specifically tested. These include small fiber neuropathy; a possible syrinx (*vide infra*); leprosy, which causes anesthetic spots in the skin; or possible malingering.

A Method

1. Ask the patient to close his eyes, touch him with a sharp pin on a normal part of his skin, and tell him that, "This is sharp." Then touch him with the dull end of the pin and tell him that, "This is dull." Have the patient identify the sharp sensation to be sure he has understood the instructions before proceeding to the areas where abnormal results may be obtained.
2. Apply the sharp and dull parts of the pin in a random sequence and ask the patient to identify them. Seven correct responses in a row is statistically significant and is evidence for intact sensation.

What kind of pin? The use of a single pin for all patients, as was standard practice in the past, is no longer advisable. Viruses, slow viruses, virions, and prions could be transmitted from patient to patient, especially by an examiner who stabbed vigorously to be sure of hypesthesia. Although it is not necessary to puncture the skin in order to test superficial pain sensation, this does happen from time to time. Accordingly, each patient gets his own safety pin (the head can be used for "dull"). Do not use an injection needle, as these are too sharp and often cause bleeding. Instead of a pin, you may wish to break a wooden applicator stick or tongue blade in half so as to obtain a sharp point, or use a chopstick. A handheld pencil sharpener will make a point that is perfect for testing, as well as a clean new point for each patient. Alternately, use the sharp and dull ends of a wooden toothpick.

Another Method

In earlier days, neurologists used a Wartenberg wheel, a series of sharp arms radiating out from a roller hub, which can be lightly passed over a large area, producing a relatively uniform "sharp" stimulus at regular intervals. They asked the patient to report any change in the sensation.

With this method, there is no control "dull." Also, there may be bizarre responses due to the stimulus-response summation from many points within a segment.

Although the test does not puncture the skin or cause bleeding if properly done, it has seldom been used since the 1980s because of the threat of litigation over alleged disease transmission. The question of whether or not there has been a slight puncturing of the skin is in the domain of metaphysics (it being impossible to prove a negative proposition), and it is generally impractical to sterilize the device between uses.

A chrome-plated Wartenberg wheel is not necessary. The original device was a tailor's tracing wheel, available at any fabric shop at a much lower cost than from a medical supply store.

Localization of Lesion from Distribution of Sensory Loss

Sensory loss due to a lesion in a peripheral nerve or a nerve root should be located in the appropriate region of the skin (see Fig. 25-6).

A lesion that interrupts the ascending fibers in the spinal cord will cause sensory loss in the dermatomes below that level

(a "sensory level"). This is a key finding in spinal cord compression, which may be an acute surgical emergency.

Acute central disc herniation causes saddle anesthesia (Hall, 1983). A sensory defect involving the area innervated by S3-4, with bladder or bowel incontinence, is an indication for urgent surgical intervention in an attempt to avert permanent incontinence. The differential diagnosis includes hematoma following trauma, tumor, abscess, and severe spondylolisthesis following injury (Dorman and Ravin, 1991).

Peripheral neuropathy often causes sensory loss in the distal extremities, the "stocking-glove" distribution. Neuropathies should be symmetric. Keep in mind that compression of the median, radial, and ulnar nerves would cause a glove distribution, and compression of the tibial and peroneal nerves, a stocking distribution. Those who look for such causes with a view to surgical correction find them more often than those who do not.

The effect of lesions in the cerebral cortex can be predicted from the homunculi (Figs. 26-31 and 26-32), which were constructed from data gathered by direct intraoperative stimulation of the brain of a conscious patient. You might want to compare them with results obtained in your own patients in the era of the CT scan and MRI.

Findings that do not correspond to the neurologic anatomy may be attributed to problems in the higher cortical centers (*vide infra*).

Do not attempt to memorize the figures; your time is better spent examining patients. However, your examinations will be better if you have an idea of the patterns that you are looking for. Carry around a map like that in Fig. 25-6 in your pocket notebook. Refer to it after examining a patient. You may then wish to reexamine the patient.

When testing for sensory deficits, a good maneuver is to have the patient draw out the perceived deficit on his skin. Begin your testing in the center of the region so indicated and work out to the periphery (S. Horenstein, *personal communication*, 1988).

Deep Pain

Deep pain, or noxious deep pressure, is different from other proprioceptive sensation in that the fibers ascend in the lateral spinothalamic tracts, which are also tested by superficial pain. Formerly, the absence of deep pain was sought as an early sign of tabes dorsalis. Today, it is primarily sought as evidence for brain death.

The absence of deep pain is eponymized according to the part of the body that the examiner squeezes. The Achilles tendon is Abadie's, the testicle is Pitres's, and the ulnar nerve is Biernacki's. The eyeball and the ovary have not yet been claimed.

Light Touch Sensation

Light touch is tested for with a camel's hair brush or a wisp of cotton. It is most often tested on the face to check the various branches of the trigeminal nerve or in a case of suspected syringomyelia.

Temperature Sensation

Temperature sensation is not usually checked routinely because it is carried in the lateral spinothalamic tracts, which have already been tested with pinprick. However, in cervical syringomyelia, the syrinx may occur at the site of fiber decussation and produce the puzzling result that pain sensation is decreased, whereas light touch is intact. In this setting, temperature testing is used as the "tiebreaker" and usually reveals that pain and temperature sensation in the area served by the involved segment are clearly decreased or missing, whereas light touch (carried in the anterior spinothalamic tract) is intact.

Temperature sensation may also be checked in suspected malingerers. They may not know that pain and temperature are carried in the same fibers and may thus be confused about which side should feel hotter or colder (L. Huntoon, *personal communication*, 2004).

A Method

Although considerable blarney has been spoken about the importance of using warm or cold water of specific temperatures, the point to remember is that the water should be neither so hot nor so cold that it produces pain in addition to temperature sensation.

Similarly, the two temperatures must be far enough apart for the difference to be detectable. This is most important when using thick-walled glass test tubes. (Although metal containers are more difficult to find, they are preferable because they conduct heat much better than glass does.)

1. Have the patient close his eyes, place one of the test tubes against his skin and ask, "Hot, cold, or neither?" (It is important to include the "neither" because tactile sensation may be intact, and the overly cooperative patient may guess even without temperature sensation. By reducing the odds of success at guessing from 50% to 33%, one can more quickly and confidently complete the testing.)
2. Keep changing the areas of the test tubes that are applied to the patient's skin because the skin itself may warm the wall of a glass tube, causing false positives.
3. Similarly, it is a good idea to check the temperature occasionally by touching the tubes to your own skin.

Alternate Methods

One could use a cold object (such as a cold tuning fork) or solid objects that may be cooled in the office refrigerator to avoid the inconvenience of tubes and water.

To eliminate the confounding tactile sensation that leads the overly cooperative patient to make guess responses, one could use radiant heat (e.g., an incandescent light source pointed or focused on the skin) and thus test heat sensation only. (Although different receptors sense heat and cold, the fibers for both ascend in the lateral spinothalamic tract.)

Sensory Signs of Abnormal Activity in Higher Nervous Centers

As in all types of sensory testing, there must be internal consistency. That is, pinprick, thermal, and "tickle" sensation (a type of pain) are lost together. (When comparing the cotton on the left side to that on the right, the patient may say, "I could feel it, but it didn't tickle me" [S. Horenstein, *personal communication*, 1988].)

Patients with malingering, conversion reactions, "compensation neurosis," and hysteria may sometimes present with complaints referable to the peripheral nervous system, when the basic

problem is actually higher in the nervous system. The various motor manifestations of this diagnostic problem have already been covered. Four sensory manifestations are especially useful.

1. Lateral Anesthesia to Pinprick Ending Sharply at Midline

Also known as "sharp midline cutoff," this finding signifies that there is no peripheral neurologic explanation for the patient's problems. This is logical because the peripheral nerves from each side jointly supply the midline, where they overlap. Thus, midline stimuli can be sensed even if one side is completely anesthetic. (You will note that when you have a nerve block for your dental work, the numbness is not midline and the cutoff or demarcation area for the anesthesia is gradual rather than sharp.)

2. Sharp Cutoffs for Vibratory Sensation

Often used over the sternum, this method can also be used to find sharp cutoffs (either midline or peripheral) over other bones.

A Method

Place your vibrating tuning fork against the bone. For each trial, reposition it no more than the diameter of the base of the tuning fork, especially as you approach the area where there was a sharp border for other sensations. Patients whose "lesion" is in the higher information-processing centers may report the sharp cutoff of vibratory sensation at the same skin area as it occurred with other sensory modalities. This does not occur in patients with peripheral nerve lesions because the vibrations are amplified by the bone, and the bone vibrates for some radius around the base of the tuning fork. Patients who have not had a course in neurophysiology do not know this, and they believe that the fork is testing some purely localized skin sensation.

Some doctors feel that the hallmark of patients with the "higher" centers is their unreliability, causing the lines of sensory cutoff to shift when the patient was examined repeatedly with the same modality. Thinking that the malingerer would "forget" between trials where the sensory cutoff was supposed to be, these doctors marked the cutoff in plain view of the patient. This maneuver assumes that malingering patient would not notice the line! To get around this new problem, other doctors marked the line in a different location from the finding, believing that if the patient, on second testing, indicated a cutoff at the marked line, the examiner had demonstrated a shifting cutoff. This practice is also to be eschewed because some overly cooperative patients will follow the implied suggestion even though they are not malingerers.

An Alternate Method

Place a quarter or other coin in the midline or over the sharp cutoff, and then place the base of the vibrating tuning fork against it so that the entire coin vibrates. Patients who are composing a neurologic examination, for whatever reason, may report that they feel the vibrations only under one half of the coin (e.g., 12 1/2 cents of vibration.)

Another Method

In the case in which you mark the sharp cutoff line of the skin, try sliding the "insensitive" skin over the sensitive bone and repeating the test. Also try sliding the "sensitive" skin up over the insensitive bone and repeating the test. The patient who is "composing a neurologic examination" may "regain" vibratory sensation over previously insensitive bone (and lose it over the previously sensitive bone) because he believes the sensation to be carried by the skin.

3. Topographic Confusion

This third gambit (after Bowlus and Currier, 1963) is actually a variation of a traditional children's game.

A Method

Stand in front of the patient and tell him to mimic your actions exactly.

1. Hold your arms forward, extended at the elbows, with the palms facing each other.
2. When the patient has copied you exactly, quickly (as if testing him for his reaction time) rotate your wrists 180 degrees so that the thumbs are now pointing down, with the palms facing laterally. (If you did not play this game as a child, practice now so that the motions will be second nature when you do it on a patient.)
3. Flexing your arms at the elbows, let your hands cross over and under each other in the midline so that the palms now face each other again with the thumbs still pointing toward the floor (Fig. 26-34A).
4. Now clasp your hands together with the fingers from each hand alternately placed. Your arms, hands, and body should form a sort of crude figure eight (Fig. 26-34B).
5. Bring your clasped hands under your chin. (To do this, move both elbows first out then down.) The thumbs will now be farthest from you (Fig. 26-34C).
6. Looking down your fingers, you will be confused as to which side the fingers are coming from. The patient would also be confused if he looked, but he is looking at you for the next instruction because he believes that you are testing some motor function.
7. Say, "Keep your hands clasped just like that for a minute," as you release your own clasped hands and pick up the examining pin.

   Note that the distal phalanges are on the same side of the clasped fingers as the side of the body they are from. But the middle digits resemble so many sausages squeezed together. There is an uncanny ignorance of the viewed parts of one's own anatomy. (This explains why this was a popular children's game in the pretelevision era, when children were more easily amused than today.) The test is based on this ignorance.
8. Say to the patient. "I am going to stick two fingers. Tell me which you *cannot* feel—the first or the second."
9. Jab any two adjacent fingers.

The neurologically impaired patient will not be able to feel the fingers whose distal phalanges are on the side of the hemianesthesia. They will make an immediate response. (However, these genuine peripheral neuropathy patients often ignore your instructions and tell you which finger they *can* feel.)

The person whose symptoms are not caused by a peripheral lesion has a completely different response. He will be stumped and will often be unable to answer quickly without thinking, although he will usually say something while trying to figure out which finger he is not supposed to be able to feel. Sometimes, he will release

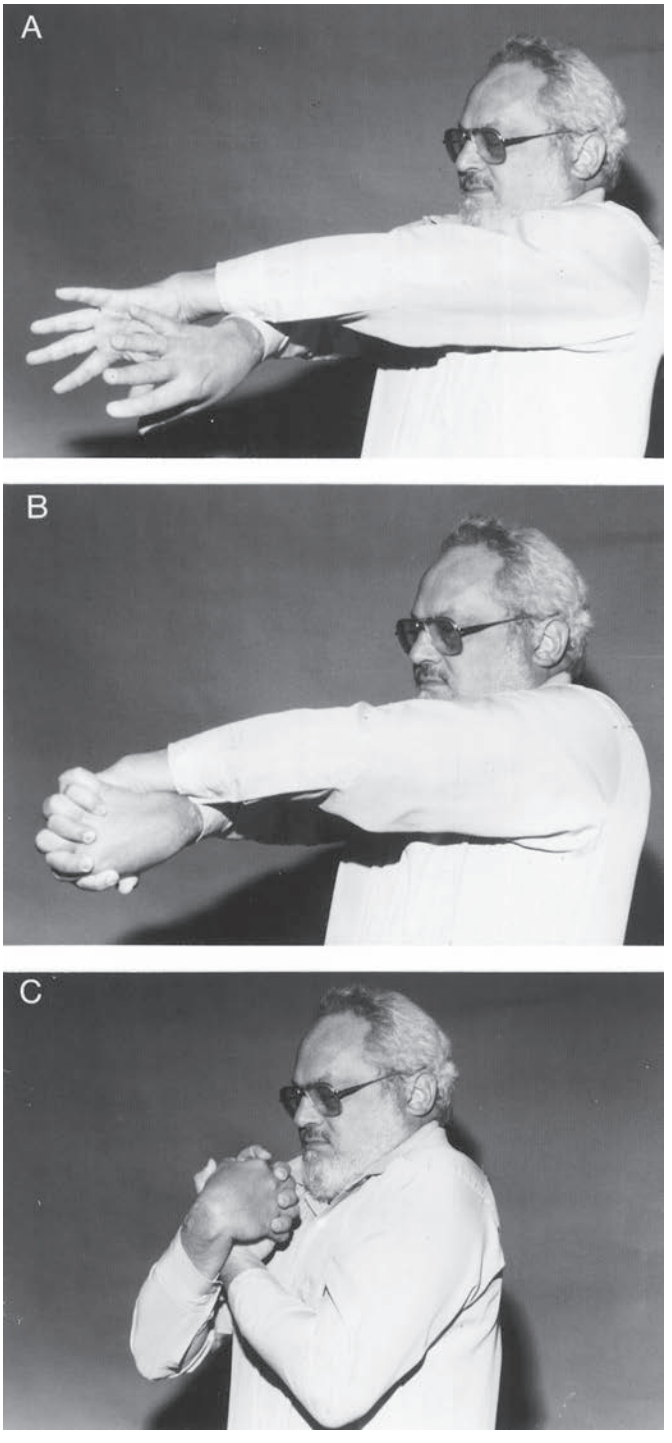


FIGURE 26-34 Positioning the hands for the topographic confusion test for hemianesthesia. The patient, who unlike the model will not be anticipating a flashbulb, should keep his eyes open throughout the test (see text).

his hands and "quit." Sometimes, he can be hurried into making an answer before he has figured out the topography of his clasped fingers. He might say that he felt no pin with either finger or that he felt it with both. These are equally bogus because any two adjacent fingers must come from opposite sides of the body.

To convince yourself of how difficult this test is for malingering patients, have a volunteer pretend that he has diminished sensation on the left. Have him place his hands on the table and ask which side a pinprick feels sharper. He will respond immediately. Then have him assume the position shown in the figure and repeat the test.

A Caveat: Definition of "Higher Centers." Be not too quick to judge. Although the detection of the entity "malingering" makes assumptions about the higher center's representation of motivation, parietal lobe lesions can also produce some interesting examination results (see above). For instance, some patients with parietal lobe lesions will also be unable to do this particular test.

A Variation. This test may be converted to a test of motor function by pointing to—not touching—any two adjacent digits, beginning with the "healthy one," and asking the patient to wiggle the fingers.

4. Another Confusion Technique

This final test works only with very simple people.

1. Ask the patient to close his eyes.
2. Beginning on the healthy side of the cutoff line, begin rhythmically sticking the patient with the pin.
3. As you continue to move toward the cutoff line, ask the patient, "Can you feel that?"
4. When the patient answers in the affirmative, say, "Good. Now say 'yes' each time I stick you and you can feel it, and say 'no' when you cannot feel it."
5. At a place on the healthy side of the cutoff line, continue rhythmically sticking the patient so that he gets in a few "yeses." Then quickly move the pin-sticking at the same rhythm so that you reach the cutoff line in about two beats. Continue sticking as you move across the line.

The person with a peripheral neuropathy will simply stop responding when you cross the line.

Some persons with disease of the higher centers will say "no" each time you touch them once you have crossed the line. (Of course, if they had no sensation, they would not be able to tell when you were touching them.)

A positive test is so amazing the first time you observe it that I suggest resting your pin in one "anesthetic" place and slightly varying the rhythm so as to convince yourself that you are not getting automatic "noes."

A Caveat. To get results on these tests, you should be quick, professional, brusque, and almost bored in manner. You should remember that although these tests are tricks in a sense, you are still working for the patient. You are using these tricks not to hurt or fool him but rather to solve problems for him. The purpose of the tests is not to abuse or humiliate patients.

If the test is positive, I sometimes say to the patient, "This will go away in a few days." In others, I might refer the patient for evaluation for long-term psychotherapy. In some cases, I might confront the patient, pointing out that his nervous system is working better than he thinks, taking care to do so in a positive and encouraging way. At other times, I have encouraged insurance companies to go to trial, or at least to take my deposition, because in patients with "compensation neurosis," the findings do not get better until the trial is over or the case dropped.

There is no pat rule for all patients in whom these tests are positive except one: You are still working for the patient, albeit in a somewhat paternal fashion.

Autonomic Nervous System

Examination of the Skin

The normal vasodilation that follows a scratch is a simple test of the intact autonomic nervous system. This test may be formalized and exaggerated as the triple response to the intradermal injection of 0.1 mL of 1:1,000 histamine phosphate (DeJong, 1979).

Sweat Test

A simple sweat test consists of placing the patient in an uncomfortably warm room and observing the skin with a magnifying lens.

Alternate Stimuli

If a hot room is not available, heating blankets or a rack of heat lamps may be used. Pilocarpine injections should be avoided because they are unreliable.

Alternate Detectors

Drag the bowl of a spoon across the skin. If there is no sweating, it drags; but if there is sweating, it slides. Or, apply a piece of tissue or paper towel, say to the forehead and observe whether only one side is wet.

The various indicator dusts that turn color when wet are useful for formal presentations but are not needed for close work by the individual physician. They should specifically be avoided in the hospital as they stain the bed linens, in some cases permanently.

Finger Wrinkling

Normally, when the hands are immersed in water at 40°C for 30 minutes, the volar surfaces (which are devoid of sebaceous glands) wrinkle or pucker or "prune." This sign is lost in diabetic autonomic neuropathy, in Guillain–Barré syndrome, in the distribution of the median nerve in median nerve neuropathy, in postsympathectomy states, and in an anesthetized finger (ring block) (Bull and Henry, 1977). The fingers may also fail to wrinkle in cases of severe edema.

See Chapter 25 for the use of this test in patients with hand injuries.

Postural Hypotension

Postural hypotension (see Chapter 6) is a useful autonomic sign, assuming that one has eliminated volume depletion as its etiology. (In autonomic dysfunction, in contrast to volume depletion, the pulse rate fails to rise.) The presence of a pressor and/or pulse response to mental arithmetic localizes the lesion to the central afferent limb.

Generalized Autonomic Failure

Widespread abnormalities of the autonomic nervous system are seen in patients with amyloidosis, and should be sought in patients with peripheral neuropathy of unknown cause. Symptoms include pupillary (blurred vision or problems with glare); secretomotor (dry eyes or dry mouth); sudomotor (gustatory sweating and heat intolerance); vasomotor (excessively cold hands or feet with discoloration); orthostatic; gastrointestinal (nausea, bloating, incontinence, diarrhea, obstipation); genitourinary (urinary incontinence or retention); and sexual dysfunction. Tests include the tilt test and response to the Valsalva maneuver (Chapter 6), the oculocardiac reflex (this chapter), and the cold pressor test (Wang et al., 2008).

A Syndrome of Sympathomotor Dysfunction

The once common childhood disease called *acrodynia* (see Chapter 7) features generalized sympathomotor dysfunction, with cutaneous vascular alterations leading to a pink color of the tips of fingers, toes, and nose; hyperhidrosis; hypotonia; hypertension; tachycardia; and photophobia. A case was described after a 200-mL bottle of mercury spilled on the couch and carpet in a room where a child played (Dinehart et al., 1988).

Intracranial Lesions

Evidence for space-occupying or vascular lesions (such as tumors, hemorrhages, arteriovenous malformations, or embolic problems) may be sought by ophthalmoscopic examination (see Chapter 10), auscultation for bruits (see Chapters 9 and 18), and thorough neurologic examination.

The most common intracranial lesion is an infarction or hemorrhage presenting as a stroke. Stroke is the most common serious neurologic disorder seen in a general hospital. However, about 13% of patients initially diagnosed with stroke are finally determined to have some other condition, most commonly unrecognized seizures, confusional state, syncope, toxins, neoplasms, or subdural hematoma (Goldstein and Matchar, 1994). Strokelike episodes can also be part of the mitochondrial syndrome, an inherited condition consisting of mitochondrial encephalomyopathy, lactic acidosis, and strokelike episodes (MELAS). This progressive neurodegenerative disorder may possibly be unmasked by statin-induced CoQ10 deficiency (Thomas et al., 2007).

Before beginning aggressive antithrombotic therapy, it is critical to distinguish ischemic from hemorrhagic stroke. Findings that suggest hemorrhage include the presence of coma on arrival, vomiting, complaint of severe headache, warfarin treatment, systolic blood pressure greater than 220 mm Hg, or blood glucose level greater than 9.4 mmol/L (170 mg/dL) in a nondiabetic patient. The presence of any one of these more than doubles the odds of hemorrhage (LR + = 2.39), and the absence of all of them decreases the odds by one third (LR − = 0.35) (Goldstein and Matchar, 1994).

Cardiovascular and Chest Examination

In patients with stroke, it is especially important to carefully examine the heart as a potential source of emboli (see Chapter 17). Especially in younger patients, a patent foramen ovale (PFO) may be the route of embolism. In patients who have sustained trauma, consider the fat embolism syndrome, in which perivascular hemorrhages and hemorrhagic infarcts occur. The classic triad of dermatologic, respiratory, and neurologic signs does not always occur. The CT scan may not show abnormalities; MRI is more sensitive (Finlay and Benson, 1996).

In patients with a mass lesion, do not overlook the lungs as a common source of metastatic tumor or as another focus of a disseminated infection. An aphorism from the Neurological Institute at Columbia-Presbyterian Medical Center (admittedly in the days before CT scans and MRI) was that the most important X-ray on the neurology service often turned out to be the X-ray of the chest.

Many cerebral complications of pneumonia have been described in the past, sometimes after the pneumonia had resolved. These included seizures, athetosis, hemiplegia, aphasia, and altered mental status. Their severity did not correlate with the severity of the pulmonary involvement. Autopsies showed widespread petechial hemorrhage, vascular congestion, and swelling or lysis of neurons (Baker and Noran, 1945). If autopsies with brain cuttings were still routinely performed, we might be able to investigate the frequency of such findings in the antibiotic era.

Selected Stroke Syndromes

Parietal Lobe Syndrome: Classic (Topographic)

Description

Some of the parietal lobe syndromes are still useful in predicting the location of an early ischemic stroke, even in this day of sophisticated CT and MRI.

1. Parietal lobe lesions may interfere with the visual pathways and produce a lower homonymous quadrantanopia (in the ipsilateral nasal field and contralateral temporal field).
2. A gaze preference (see text earlier in this chapter) may result from a parietal lobe lesion.
3. The pure right parietal lobe sign most often seen may be called a dressing apraxia, in which patients will try to put their arms through their pant legs and their shirts on as their underwear (M. Schlitt, *personal communication*, 1999). This is actually not a true apraxia, but a manifestation of a hemineglect syndrome.
4. Parietal lobe lesions may produce loss of sensory modalities or, more likely, loss of all sensory representation of the affected surface. These lesions may be very difficult to detect unless one uses Bender's technique of *DSS*. If the clinician taps simultaneously on both sides of the body (e.g., the face; see text earlier in this chapter), at exact mirror image points, patients with a parietal lesion will not feel the stimulus on the side opposite the lesion (i.e., the part of the body served by the afflicted cortex). However, the stimulus will be perceived if the same spot is touched singly! This interesting phenomenon is also known as *parietal cortical extinction*.
5. More posteriorly placed parietal lobe lesions may produce peculiar sensory syndromes characterized more by loss of awareness of the part than by loss of a discrete modality. With *implicit neglect*, the patient verbally admits that there is a problem, but operationally and behaviorally ignores the problem in his contemporary behavior and his plans for the future. With *explicit neglect*, the syndrome itself is denied, as in the final worst stages of cortical blindness (*vide infra*).

One example of the latter is *contralateral* (to the lesion) *neglect* (hemineglect), in which the patient pays no attention to the limb or other body part whose parietal lobe representation has been afflicted. The patient may not wash it, or in some cases move it, even though motor function is perfectly intact. However, contralateral neglect is not of itself diagnostic for parietal lobe lesions and may be seen with temporal lobe lesions, occipital lobe lesions, frontal lobe lesions, or lesions of the connections between them.

In other versions of contralateral neglect, there are various forms of agnosia in which the patient may variously deny that there is anything wrong with the body part or even that it belongs to him. Or there may be preservation of sensation with an alteration in the dimensions of identity, depth of sensation, and general stereognosis (not simply position sensation).

With right parietal lobe lesions, patients frequently have anosognosia (failure to recognize that something is wrong with them) and asomatognosia (failure to recognize their own body parts on the left side). If you ask such patients to show you their left hand, they will typically look at their right; or if they recognize that this is not correct, they will give up the search altogether.

A remarkable case of visual agnosia is described in a classic collection of clinical essays (Sacks, 1985). This patient saw the world in terms of lifeless abstractions: He could recognize (and name) an eicosahedron, but not his wife. He could describe a glove as a "continuous surface, infolded on itself, [that] appears to have … five outpouchings, if this is the word," but had no concept that it might fit a hand.

These forms of agnosia may also be part of other peculiar syndromes, which may tempt the superficial physician to believe that he is dealing with some sort of malingering. One such syndrome, long a snare to the gullible, is Gerstmann syndrome. (Although some authorities believe that Gerstmann syndrome is simply a concatenation of events with no specific localizing significance, it is peculiar enough to be noted.)

Gerstmann syndrome may be seen in middle cerebral artery strokes, especially on the left. It comprises acalculia, alexia, finger agnosia, and right–left confusion. The latter is not simply the inability to name right and left parts but an unawareness of their distinction. This confusion was best illustrated by a patient of Dr Andy Lonigro of Missouri.

After completing the examination of one leg, which the patient had extended out to him, Dr Lonigro released his grasp on that leg and said to the patient, "Now, give me your other leg."

The patient did not move, but merely glanced at Dr Lonigro quizzically and said, "But Doctor, that is my other leg."

For some other clinical histories, see Sacks (1985).

Finger agnosia may be detected in severe cases by grasping the patient's fingers in such a way as to intertwine alternately the examiner's own fingers with those of the patient. When the digital braids are presented to the patient, he is unable to say which of the fingers belong to him.

Assessing Density (Severity)

There is a hierarchy starting with mild disease and progressing to dense (severe) disease.

Tactile Sensation. For this modality, the mildest disease is that which is only detected using the technique of DSS. Next there is impaired localization of the singly presented stimulus. At the next level, there is inability to perform the tests for two-point discrimination (*vide supra*), inability to identify numbers drawn on the tip of the finger (where there are abundant nerve endings, as opposed to the palm on which there are few), and inability to recognize (not just to name) objects placed in the patient's palm (out of sight).

This is tactile agnosia. Then, there is inability to dress that side of the body. If the patient wears spectacles, he may put them on so that they fit only the good side. At the very worst level of function, the patient will deny the limb on the affected side.

Vision. A similar hierarchy exists for visual events. At the first level, the only way to detect a defect is by DSS (e.g., hold up two pens, one in each lower temporal quadrant at the same relative position, and determine whether the patient sees both or only one). At the next level, the patient loses his capacity for linear bisection, and with still more severe disease, depth perception is lost.

A Method for Linear Bisection. Hold your tape measure horizontally in front of the patient so that any numbers facing him are upside down. Instruct him not to look at the numbers and to point to the "middle" of the segment. Healthy persons will come close to the middle (say about 50 cm on a 100-cm tape); patients with parietal lobe disease will deviate to the good side in proportion to their defect.

Checking Depth Perception. When asked to touch your finger, the patient will overpoint at the target, but only when it is held on the side served by the damaged parietal lobe. At the next level of dysfunction, the patient will lose the ability to construct overlapping polygons, either with matches or toothpicks or when drawing card No. 8 of the Bender Gestalt test. Finally, with the most severe lesions, the patient is cortically blind and not aware of the fact (Anton syndrome).

A Case Report. Dr Lawrence Huntoon saw a patient with vague sensory symptoms in her left arm. CT scan was normal. Primary sensory testing (touch, pin, vibratory, and proprioception) and the remainder of the neurologic exam were normal with one exception: with her eyes closed, she could not identify objects placed in her left hand (asterognosia); nor could she perceive letters or numbers traced in the palm of her left hand (agraphognosia). When the CT scan was repeated the following day, a small right parietal ischemic infarct was confirmed. A year later, the patient could describe objects placed in her left hand ("cold, round, sharp") but could identify them instantly ("bottle cap") when placed in her right hand.

Cerebral Hemorrhage

Hypertensive patients tend to have gray matter cerebral hemorrhages in an isohexahedron bound by the corpus callosum anteriorly, posteriorly, and superiorly; the thalamus–hypothalamic border inferiorly; and the claustrum laterally. Hemorrhage most commonly occurs in the globus pallidus, putamen, thalamus, external capsule, parietotemporal junction, cerebellum, and pons. These hemorrhages are often related to degenerative microaneurysms. Outside this isohexahedron, the gray matter hemorrhages are predominantly the result of other causes such as trauma or the cerebral bleeding that frequently ends the life of patients with severe liver disease.

The likely etiology of brain hemorrhages based on location can be very important in the medicolegal arena. Dr Lawrence Huntoon reports a case in which a plaintiff's attorney tried to attribute a patient's hemorrhage and death to a motor vehicle crash that had occurred months before, at which time the CT scan was negative. The location of the hemorrhage in the putamen, however, pointed to her long-standing hypertension as a far more likely cause.

Wallenberg Syndrome

Wallenberg syndrome is also known as lateral medullary syndrome, or lateral plate syndrome, from the anatomic area affected. It is also called *the syndrome of the posterior inferior cerebellar artery* (*PICA*), after the vessel whose insufficiency most commonly causes it; but actually, this watershed area can become ischemic due to disease in other vessels, including the vertebral artery and the superior, middle, and inferior lateral medullary arteries.

Significance. This syndrome is important for the generalist for a number of reasons: First, it is the most frequent of the medullary syndromes. Second, it is a syndrome of crossed sensory (pain and temperature) deficit, and therefore likely to be misinterpreted by some psychologically suspicious but anatomically lax physicians. Finally, it has an excellent prognosis for at least partial recovery of function, which can be gratifying for the practitioner, albeit a pitfall for the unsophisticated designer of therapeutic trials.

Appearance. Because it is a syndrome, not all of the findings will "run together" (syndrome) in the individual case. All the findings are ipsilateral to the lesion, except one: *the loss of pain and temperature sense on the limbs and trunk, which is contralateral to the loss of pain and temperature on the face*. This harlequin sensory defect is the clue to the diagnosis, which in the individual patient can be associated with a large variety of additional defects and their historic counterparts. These include palsies of cranial nerves VI, VII, and VIII; and paralysis of the soft palate, larynx, and pharynx, with their presenting symptoms of dysphagia and dysphonia. The corneal reflex may be lost and there may even be Horner syndrome. Occasionally, cerebellar involvement may produce a synergy and hypotonia. (Again, all of these defects are ipsilateral to the lesion.) Cerebellar involvement may also be responsible for the "midline symptoms" of vertigo, nausea, and vomiting.

It should be specifically noted that there may be ataxia with failing toward the side of the lesion, but true motor weakness of the limbs is not seen and should suggest another diagnosis.

Locked-in (De-efferented) Syndrome

Although caused by the same brainstem lesions that often destroy the reticular activating system (RAS) (*vide infra*), the locked-in syndrome is not accompanied by impairment of consciousness, possibly because the reticular formation on one side is spared. This most devastating of neurologic syndromes has been likened to "a living death." The patient can communicate with the examiner by blinking his eyes (once for "yes" and twice for "no"; or by counting with eye blinks). Trousseau had such a patient, whom he described to his friend Alexander Dumas (fils), who described the syndrome in his short story "The Notary." In this story, a young girl recites the alphabet while the patient selects the correct letter by blinking, thus spelling out whole words and sentences. The elder Dumas also portrays a patient with this syndrome in his novel *The Count of Monte Cristo*: Noirtier de Villefort, afflicted with "apoplexy, that thunder bolt that strikes you without destroying you." Recovery has occurred (Ostrum, 1994).

Although poorly understood from a neuroanatomic viewpoint, central pathways mediating emotion are often not intimately associated with other motor fibers. On the basis of this knowledge and the belief that humor can often make patients feel better, Dr Huntoon tried telling Jerry Classen jokes to a man suffering from locked-in syndrome. Much to everyone's surprise, the patient grinned from

ear to ear. The family brought in a Jerry Classen tape and played it for the patient from time to time until he died a few weeks later.

Bilateral Frontal Lobe Isolation

Bilateral frontal lobe isolation presents as transcortical motor aphasia. Patients with this condition do not speak spontaneously (although they may grunt from time to time). It requires a great deal of input to get them aroused sufficiently to speak; but when they do, they are quite fluent. Repetition of the test phrases is clear and accurate and they can read instructions, even aloud, but their writing is poor. Because of their usual silence and their general lack of motor spontaneity, they are often erroneously believed to have coma vigil (*vide infra*). Dr Simon Horenstein of Missouri points out that if you throw a damp (soft) washcloth at such a patient, he will leap into action and catch it. (The cloth should be soft so that the patient will not be injured in the event that your diagnosis is incorrect.)

Lesions of the medial anterior portion of the frontal lobes can present in exactly this way also.

Selected Neurologic Symptoms or Diagnoses

(Landry–) Guillain–Barré (–Strohl) Syndrome

Guillain–Barré syndrome is predominantly an ascending paralysis accompanied by "albuminocytologic dissociation" (i.e., the cerebrospinal fluid shows an elevated protein but relatively few, if any, cells). It may follow viral infections, inoculations, mycoplasma infections, Lyme disease, or surgery, and it is more frequent in the setting of lymphoma or lupus erythematosus. None of these are essential to the diagnosis (Committee, 1978).

The diagnosis requires progressive weakness of more than one limb, with areflexia. The diagnosis is in doubt if there is marked persistent asymmetry of weakness, bladder or bowel dysfunction at onset, or a sharp sensory level.

Transient Global Amnesia

Transient global amnesia is a unique, self-limited, and generally benign though alarming phenomenon that occurs in middle-aged patients. It is precipitated in about one third of patients by an emotional experience, intense pain or cold, or strenuous physical exertion especially at high altitude. Patients may have a sense that "something is wrong," but usually exhibit a profound lack of insight and are brought to the emergency room by others. During the episode, patients are unable to form new memories and also exhibit a profound retrograde amnesia of up to 8 hours. They are disoriented to time and place, but do know their names, and usually (60% to 90% of the time) ask the same questions repeatedly. They are attentive and can follow complex commands, carry on complex physical activities, and solve problems. They can learn a list of words if they are able to rehearse but rapidly forget it if distracted. The diagnosis can be made on purely clinical grounds, providing that focal findings are excluded on careful examination, and a witness has observed the patient to reduce the likelihood of missing other manifestations of a complex partial seizure. The syndrome should resolve spontaneously within 24 hours, with amnesia occurring only for the duration of the attack. About 3% to 20% have a recurrent attack within 5 years, and such patients have a higher risk of developing a seizure disorder (Brown, 1997a). About 70% of patients have a history of migraine (Patten, 1996).

There are anecdotal reports of transient global amnesia several weeks after beginning statin drugs for hypercholesterolemia, in at least one case recurring upon rechallenge (Graveline, 2004), and a flurry of discussion on the Internet. Milder degrees of memory loss, resolving with cessation of statin drugs and recurring on rechallenge, have been reported in the medical literature (Wagstaff et al., 2003; King et al., 2003). One case of transient global amnesia has been reported after use of sildenafil (Viagra) (Savitz and Caplan, 2002). Commonly used drugs will occasionally be associated with adverse events by coincidence, but physicians need to be alert for possible causal relationships. Always take a careful history, including drugs and other potentially contributing factors.

Seizures

> *All you, healthy people, do not even suspect what happiness is, that happiness which we epileptics experience during the second before the attack. In his Koran Mohammed assures us that he saw paradise and was inside. All clever fools are convinced that he is simply a liar and a fraud. Oh no! He is not lying! He really was in paradise during an attack of epilepsy from which he suffered as I do. I don't know whether this bliss lasts seconds, hours or months, yet take my word for it, I would not exchange it for all the joys which life can give.*
>
> —Fyodor Mikailovich Dostoyevsky, quoted in Klawans (1990)

A seizure is a paroxysmal and transitory disturbance of brain function, manifested by an altered state of consciousness and variable motor manifestations, from a brief cessation of activity in petit mal to generalized tonic–clonic convulsions in grand mal epilepsy. In about 60% of cases there is an aura, such as a sense of déjà vu, a sensory hallucination, or occasionally the type of phenomenon described by Dostoyevsky above.

The differential diagnosis includes syncope, which usually develops more gradually, is preceded by a sense of faintness, and is provoked by some identifiable event such as hemorrhage, emotional shock, pain, or standing for long periods. In syncope, the patient is limp. The presence of slight rigidity, twitching, or incontinence favors seizure, although all of these manifestations can occur in severe syncope (Brain and Walton, 1969), especially cardiac syncope (Stokes–Adams attack) or carotid sinus syncope. Such attacks generally occur suddenly or with only a momentary sense of weakness, and a period of confusion or neurologic abnormalities may follow recovery. Such patients have an ashen-gray pallor.

If a seizure is observed, protect the patient from injury, and observe carefully the sequence and types of movements of eyes, face, and limbs. Some seizures begin focally and then generalize. Check respirations, cardiovascular findings, and associated findings such as sweating and pallor (often found with syncope), incontinence, and a postictal state of confusion or stupor. If you do not observe the seizure yourself, ask any witnesses about these findings.

Status epilepticus—the occurrence of repeated seizures without recovering consciousness between episodes—is a life-threatening emergency. Delayed treatment is less likely to be effective. Mortality is 60% if untreated and 10% even with skilled management (Patten, 1996). Remember to include status epilepticus or a postictal state in the differential diagnosis of coma.

Seizures may either be idiopathic or secondary to a wide variety of structural or metabolic disturbances. They always deserve a thorough workup. With any type of episodic neurologic symptoms or signs, or periodic bizarre behavior, seizures should always be considered. Dostoyevsky's supposed psychiatric problems may have been explained by his epilepsy—as were those of Prince Myshkin in *The Idiot* (Klawans, 1990).

Pseudoseizures are surprisingly common, especially while a compensation claim is pending. They also occur in epileptics, who may use them to avoid unpleasant situations. Findings that point to pseudoseizures include: occurrence in public (especially the waiting rooms of neurology clinics); a characteristic opisthotonic type of posture, with the patient lying on his side; eyes held tightly shut (rather than open and rolled back); and semipurposive limb movements (Patten, 1996).

One patient known to Dr Huntoon had a "seizure" every time he was brought before a judge for sentencing. Each time, an ambulance was called and he was transported to the emergency room, where a CT scan, electroencephalogram (EEG), and blood tests were done. Each time, sentencing was postponed. When an EEG performed during a pseudoseizure was normal, the diagnosis was made. After sentencing, he was never seen in the emergency department again.

Headache

Headache is one of the most common complaints, accounting for up to 40% of physician consultations. A complete treatment of the "scan-negative headaches," which are generally distinguished by careful history, is beyond the scope of this text (Patten, 1996). Suffice it to say that headache is usually a minor part of the history in a patient with a serious etiology, with a few exceptions that are medical or surgical emergencies: subarachnoid hemorrhage from a leaking vascular malformation (also see Chapters 9 and 10), temporal arteritis (see Chapter 18), and meningitis.

With subarachnoid hemorrhage, recent recurrent premonitory headaches can mislead the clinician into misdiagnosis of a benign cause. Right-sided aneurysms are missed more frequently, perhaps because right hemispheric dysfunction may lead to neglect or lack of concern by the patient. Sudden onset of an extremely severe ("thunderclap") headache, with or without earlier mild headaches, and accompanying symptoms of nausea, vomiting, vertigo, syncope, altered consciousness, and a stiff neck (*vide supra*) raise the likelihood of subarachnoid hemorrhage. The patients most likely to benefit from urgent aneurysm resection are the ones most likely to be misdiagnosed. A low threshold for CT scanning is thus recommended (Kowalski et al., 2004).

Migraine

Migraine is a separate category because headache is not the sole symptom of an attack nor is it a necessary feature. Classic migraine begins with an aura, which sometimes constitutes the sole manifestation of an attack. Common migraine is associated with classic head pain symptoms and perhaps nausea, photophobia, and sonophobia, but no aura. The classic headache is throbbing and frontotemporal in location. Other patterns also occur. Migraine equivalents include periodic and recurrent attacks dominated by nausea and vomiting, abdominal pain, fever, drowsiness, mood changes, diarrhea, or other features. The patient may experience transient neurologic symptoms possibly related to vasospasm, without a headache.

The types of migraine aura are exceedingly varied. Examples are simple and complex sensory hallucinations, intense affective states, speech disturbances, distortions of time and space perception, and trancelike states, described by Sacks in his classic work on the subject. Differentiating migraine from epilepsy is sometimes difficult, especially if there are complex auras or a positive family history for epilepsy. The following distinctions may be helpful (Sacks, 1973):

1. Visual symptoms are far more common in migraine and often have a characteristic form—scintillating and negative scotomata—not seen in epilepsy.
2. Generalized convulsions are common in epilepsy but so rare in migraine as to cast doubt on the diagnosis.
3. Loss of consciousness is common in epilepsy but rare in migraine.
4. It is rare for the dreamy or dissociative states of migraine to reach the intensity of those seen in temporal lobe seizures (e.g., automatisms followed by amnesia), and it is rare for epileptics to experience the protracted delirium that may accompany and greatly outlast migraine auras. Dreamy or dissociative states associated with headaches should be studied with EEG to help make the distinction between migraine and seizures.

Migraines may mimic a variety of neurologic syndromes, including transient ischemic attacks (TIAs). Migraine sufferers may indeed be at a higher than average risk for a stroke. Some variants, including hemiplegic or ophthalmoplegic migraine, can be followed by long-lasting neurologic deficits. Migraine may mimic movement disorders, BPPV, and other disorders. A family history of "sick headaches" favors migraine but other diagnoses must be excluded (Parker, 1997).

In double-blind controlled studies, migraine was relieved by hyperbaric oxygenation (HBO) in 70% of patients, while about 30% had relief on placebo (breathing a 10% oxygen/90% nitrogen mixture under 2 atmospheres pressure). Neurologic manifestations of migraine have also reportedly been relieved by breathing oxygen under pressure. Transcranial Doppler studies during HBO are compatible with hyperoxic vasoconstriction. Such studies may help elucidate the mechanisms involved in migraine even if the treatment modality is inaccessible to most patients (Bookspan et al., 1999).

A relationship between migraine with aura and a cardiac right-to-left shunt has been reported. In one study, 41% of migraine patients had a PFO compared with 16% of controls, the prevalence of which is similar to that found in young patients with stroke. Some patients who had their PFO closed for other indications have reported cessation of their migraines or a marked decrease (Schräder, 2003; Horton and Bunch, 2004).

Multiple Sclerosis (MS)

How Urgent Is the Diagnosis?

A rather common affliction that usually begins in early adulthood and can target almost any area of the nervous system, MS may raise the question of whether you really want to make the diagnosis. The first symptoms may be mild and transient. Some patients will never have another attack and many others will be free of symptoms for years. Yet, making the diagnosis will instantly have a major impact on the patient's life. The patient may become uninsurable and find

many opportunities foreclosed because of the uncertain, possibly grim prognosis.

The aggressiveness of diagnostic efforts, say for a single mild attack of optic neuritis, depends largely on the answer to the question "to treat or not to treat." In 1877, Charcot stated that "… the time has not yet come when such a subject can be seriously considered." By 2000, many neurologists held that failure to treat at the earliest sign of disease is analogous to withholding antihypertensives until patients have a heart attack or stroke (Frohman et al., 2000).

In the past, the definition of MS was the development of lesions disseminated in time and space, that is, involving more than one area of the nervous system. "Two optic nerves are not discrete enough to be multiple, in my view," stated John Kurtzke (Kurtzke, 1985). This terminology constitutes a description, not a diagnosis. From the patient's standpoint, it would obviously be better to have one scar than many. Indeed, with the availability of MRI, it is apparent that there are usually multiple lesions, most of them clinically silent, at the first presentation to a physician.

The needed degree of diagnostic certainty is a function of available treatments. At what point will the physician recommend, and the patient accept, chronic (possibly lifelong) treatment that is very expensive, toxic, and of limited effectiveness? On the other hand, the availability of a safe treatment that might abort an episode and prevent permanent damage turns the first neurologic symptom into an acute emergency (James, *personal communication*, 2004).

Given the reputation of MS, there is a difficult dilemma: to access treatment requires a diagnosis, but how can one make the diagnosis without evoking a terrifying specter that is not applicable to most patients?

Common Signs and Symptoms

Lesions of MS can occur at any level: cerebral hemispheres, cerebellum, brainstem, cranial nerves, retina, and spinal cord. Peripheral nerves may also be involved, more frequently than previously thought (Zee et al., 1991). The most common symptoms and signs are described below.

Optic neuritis may manifest as scotomata or field defects, decreased visual acuity, color desaturation, subjectively decreased brightness, or blindness (see Chapter 10). Dull pain exacerbated with eye movement may be reported.

Diplopia may result from a sixth nerve palsy or an intranuclear ophthalmoplegia (see Chapter 10).

Sensory symptoms may include dysesthesias, hypesthesias, and various unpleasant sensations, such as a feeling that a limb is tightly wrapped.

Fatigue is extremely common and often disabling. MS is part of the differential diagnosis of the chronic fatigue syndrome.

Weakness may appear insidiously as fatigue on exertion, tripping because of a subtle foot drop, a gait disturbance, or loss of dexterity. Signs such as hyperreflexia, clonus, or a positive Babinski may precede subjective complaints.

Cerebellar dysfunction manifests as incoordination, difficulty with balance, or scanning speech.

Urinary symptoms appear at some time in most MS patients. Constipation is so common that its absence makes some neurologists question the diagnosis of MS.

The *Lhermitte sign*, an electrical-shock sensation provoked by neck flexion, is very common in MS but not diagnostic.

Heat sensitivity is very common. The *hot bath test* was once used as a diagnostic maneuver, attempting to induce new symptoms to satisfy the "disseminated in place" criteria. It is important to remember that the new manifestation sometimes proved to be a permanent deficit (L. Huntoon, *personal communication*, 2003).

In cases of suspected MS, it is important to perform a complete neurologic examination. Patients are classically said, for example, to have symptoms in one leg and signs in both. A dilated funduscopic examination is indicated.

Etiology

Current treatments for MS, including steroids and interferons, are based on the assumption that the condition is an inflammatory autoimmune disease. The laboratory model is experimental allergic encephalomyelitis (EAE). Immune phenomena can clearly be demonstrated in MS, although the same immunologic markers at the same level have been found in stroke patients (Wang et al., 1992). The autoimmune theory has been criticized (Behan et al., 2002) but is still generally accepted in 2009.

It has been noted that the pathologic findings in decompression sickness and the brain lesions in late survivors of fat embolism are indistinguishable from the plaques of MS (James, 1983). With MRI, lesions from cerebral fat emboli, like those of MS, show hyperintense areas on T-2 weighted images. Dermatologic and retinal findings (see Chapters 7 and 10) are suggestive of an embolic phenomenon, as is the clinical resemblance of some episodes of MS to a TIA. The surprisingly high incidence of transient central nervous system (CNS) deficits in apparently healthy, medically trained individuals of median age 36 (32%), with the majority being visual deficits, could represent an attack of MS, although attributed in the study to TIAs (Levy, 1988). There are even good reasons to suggest that the EAE model utilizes embolism, as the antigens must be injected in an oil emulsion or particulate suspension (James, 1983).

Subacute fat embolism could explain a number of features of MS: the topography of the lesions, corresponding to "watershed" areas of the circulation; axonal and neuronal loss; and venular damage and perivenular demyelination (James, 1982). Remarking that "disseminated sclerosis is a somewhat ridiculous disease, for it seems to obey no rules and may apparently remain inactive for 10 or 20 years," W. Ritchie Russell noted that similar changes, compatible with a small area of circulatory insufficiency, may occur in fat embolism (Russell, 1967).

Also of note is the higher prevalence of multiple hyperintense T-2 weighted densities in the brains of scuba divers with a PFO, probably secondary to gas embolization during decompression without overt symptoms (Knauth et al., 1997).

Only a few cases of MS, however, follow closely upon an episode of trauma, and the association is generally dismissed as coincidental (Klawans, 1991). Yet, almost all diseases, poisonings, and injections to which the body has been subjected have reportedly been associated with fat embolism (James, 1982). In 1993, pulmonary fat embolism was found in 92 (17%) of 527 clinical autopsies and cerebral emboli were found in 25% of these. Nontraumatic fat embolism was found in 6% of the cases (Behn et al., 1997). A suggested mechanism is agglutination of endogenous or infused exogenous fat such as Intralipid. Chylomicrons and Intralipid liposomes are known to undergo calcium-dependent agglutination by C-reactive protein, and this could play a role in nontraumatic fat embolism (Hulman, 1995).

Intraluminal fat globules smaller than 7 mm in diameter can pass through the pulmonary arteriolar network directly to the brain. Passage via a PFO or arteriovenous pulmonary shunt is another possible route (Stoeger et al., 1998).

In classic fat embolism, there is a symptom-free interval between the injury and the cerebral signs. Necropsy of an unusual patient who survived 3 months after massive cerebral fat embolism showed multiple demyelinated foci in no obvious proximity to blood vessels (von Hochstetter and Friede, 1977).

If MS is indeed the result of disruption in the blood–brain barrier due to a subacute vasculopathy, possibly caused by fat embolism, treatment should be directed at healing the wounds in the nervous system and repairing the blood–brain barrier. This is the rationale for using oxygen under hyperbaric conditions (see Fig. 11-6), a method widely used in Britain but not generally accepted in the US.

Fibrocartilaginous embolism (see Chapter 25) is another phenomenon that has been associated with myelopathy and hyperintense T-2 weighted densities on MRI. Preceding events have included minor trauma or physical exertion, often involving a Valsalva maneuver such as lifting weight from a squatting position. The course of symptoms has been described as a "spinal stroke in evolution." Previously such events were thought to be rare and to have a dismal prognosis. It is suggested that such events may be more prevalent than currently recognized. One institution encountered three cases in 1 year; the second two were suspected prior to death because of the autopsy findings in the first case (Bots et al., 1981). The condition may have a wider spectrum of clinical presentation and recovery than initially believed (Han et al., 2004). Some might be diagnosed as an "attack" of MS. Wider use of MRI of the spinal cord may be helpful.

Following the Course of Illness

Longitudinal scoring of MS is extremely important in monitoring therapy. The most widely used method is the Kurtzke Expanded Disability Score (expanded disability status scale [EDSS]), given in Table 26.11. Determine the functional status (FS) score in each

TABLE **26.11** *Kurtzke expanded disability score (EDSS)*

0.0	Normal neurologic exam (FS all grade 0); cerebral grade 1 acceptable
1.0	No disability, minimal signs (grade 1) in one FS other than cerebral grade 1
1.5	No disability, minimal signs in more than one FS other than cerebral grade 1
2.0	Minimal disability (grade 2) in one FS, others 0 or 1
2.5	Minimal disability in two FS, others 0 or 1
3.0	Fully ambulatory. Moderate disability (grade 3) in one FS, others 0 or 1; *or* mild disability in three or four FS, others 0 or 1
3.5	Fully ambulatory. Moderate disability in one FS and mild disability in one or two FS; or moderate disability in two FS; or mild disability in five FS, others 0 or 1
4.0	Ambulatory without aid or rest for about 500 m; self sufficient; up for 12 h a day despite one FS grade 4, others 0 or 1, or combinations of lesser grades exceeding previous steps
4.5	Ambulatory without aid or rest for about 300 m; may require minimal assistance or limitation of full activity; FS as for grade 4.0
5.0	Ambulatory without aid or rest for about 200 m; disability severe enough to impair full daily activity; usually one FS grade 5, others 0 or 1, or combinations of lesser grades exceeding specifications for step 4.0
5.5	Ambulatory without aid or rest for about 100 m; FS as for grade 5.0
6.0	Unilateral assistance required to walk about 100 m with or without resting; more than two FS grade 3 or higher.
6.5	Constant bilateral assistance required to walk about 20 m without resting; FS as for grade 6.0
7.0	Unable to walk beyond about 5 m even with aid; essentially restricted to wheelchair; wheels self and transfers alone; more than one FS grade 4 or worse, or pyramidal grade 5 alone
7.5	Unable to take more than a few steps; restricted to wheelchair; may need aid to transfer; FS as for step 7.0
8.0	Essentially restricted to bed or chair or perambulated in wheelchair, but out of bed most of day; retains many self-care functions; generally has effective use of arms; generally FS grade 4 or worse in several systems
8.5	Essentially restricted to bed much of day; has some effective use of arm(s); retains some self-care functions; FS as for step 8.0
9.0	Helpless bed patient; can communicate and eat; most FS grade 4 or worse
9.5	Totally helpless bed patient; unable to communicate or eat; almost all FS grade 4 or worse
10.	Death from MS
A.	**Pyramidal functions**
0	Normal
1	Abnormal signs without disability
2	Minimal disability
3	Mild or moderate paraparesis or hemiparesis, or severe monoparesis
4	Marked paraparesis or hemiparesis, moderate quadriparesis, or monoplegia
5	Paraplegia, hemiplegia, or marked quadriparesis
6	Quadriplegia

(continued)

TABLE
26.11 *Kurtzke expanded disability score (EDSS) (continued)*

B. Cerebellar functions
0 Normal
1 Abnormal signs without disability
2 Mild ataxia
3 Moderate truncal or limb ataxia
4 Severe ataxia all limbs
5 Unable to perform coordinated functions owing to ataxia

C. Brainstem functions
0 Normal
1 Signs only
2 Moderate nystagmus or other mild disability
3 Severe nystagmus, marked extraocular muscle weakness, or moderate disability of other cranial nerves
4 Marked dysarthria or other marked disability
5 Unable to swallow or speak

D. Sensory functions
0 Normal
1 Vibration or figure-writing decrease only, in 1 or 2 limbs
2 Mild decrease in touch or pain or position sense, and/or moderate decrease in vibration in 1 or 2 limbs, or vibratory (c/s figure writing) decre alone in 3 or 4 limbs
3 Moderate decrease in touch or pain or position sense, and/or essentially lost vibration in 1 or 2 limbs, or mild decrease in touch or pain, and/or moderate decrease in all proprioceptive tests in 3 or 4 limbs
4 Marked decrease in touch or pain or loss of proprioception, alone or combined, in 1 or 2 limbs or moderate decrease in touch or pain and/or severe proprioceptive decrease in more than 2 limbs
5 Essential loss of sensation in 1 or 2 limbs or moderate decrease in touch or pain and/or loss of proprioception for most of the body below the head
6 Sensation essentially lost below the head

E. Bowel and bladder functions
0 Normal
1 Mild urinary hesitancy, urgency, or retention
2 Moderate hesitancy, urgency, retention of bowel or bladder, or rare urinary incontinence
3 Frequent urinary incontinence
4 In need of almost constant catheterization
5 Loss of bladder function
6 Loss of bowel and bladder function

F. Visual function
0 Normal
1 Scotoma with corrected visual acuity better than 20/30
2 Worse eye with scotoma with corrected visual acuity 20/30 to 20/59
3 Worse eye with large scotoma, or moderate decrease in fields, but with corrected visual acuity 20/60 to 20/99
4 Worse eye with marked decrease of fields and corrected acuity of 20/100 to 20/200; grade 3 plus corrected acuity of better eye of 20/60 or less
5 Worse eye with corrected visual acuity less than 20/200; grade 4 plus corrected acuity of better eye of 20/60 or less
6 Grade 5 plus corrected visual acuity of better eye 20/60 or less

G. Cerebral functions
0 Normal
1 Mood alteration only (does not affect EDSS)
2 Mild decrease in mentation
3 Moderate decrease in mentation
4 Marked decrease in mentation
5 Severe chronic brain syndrome or incompetent

FS, Functional status score.
From Kurtzke JF. Rating neurologic impairment in multiple sclerosis: An expanded disability status scale (EDSS). *Neurology.* 1983;33:1444–1452, with permission.

system and the EDSS when you first evaluate a patient and at intervals thereafter.

As the EDSS is a fairly gross measure with a heavy emphasis on ambulation, you may also wish to devise individualized measures for each patient. Choose measures that can be repeated frequently so that day-to-day variability and long-term trends can be assessed. Patients who are inclined to undertake self-experiments with various treatments should be encouraged to keep objective data. Possibilities include: the timed stands test (see Chapter 25); timed walks or swims; maximum number of repetitions of various exercises such as sit-ups or squeezing a dynamometer; frequency of urination and volume voided; numeric scores for sensory symptoms; or reading a visual acuity card. Patients should be partners in planning their treatment regimens.

Consciousness, Stupor, and Coma

Initial Assessment of the Unresponsive Patient

A definition of altered levels of consciousness is given in Table 26.12. As soon as this state is recognized, and the ABCs (airway, breathing, circulation) are taken care of, the highest priority will be to determine the reason for the altered consciousness and to initiate appropriate care. Various portions of the examination have already been described above (see cranial nerves, posture, and vestibular signs); in Chapter 10 (pupillary and funduscopic signs); in Chapter 9 (signs of trauma); in Chapters 6, 17, and 18 (hyperthermia and cardiovascular problems); and other chapters (other signs of serious systemic disease, such as myxedema coma or thyroid storm). Vital signs and "neuro signs" (such as pupillary size and reactions, doll's eyes, posturing reflexes) should be monitored. In addition, the Glasgow Coma Scale (GCS, Table 26.13) has been adopted as a standard method. To gauge response to pain, begin by pinching the skin and progress to more noxious stimuli (such as squeezing tendons) if there is no reaction.

Some causes of loss of consciousness are listed in Table 26.14.

TABLE **26.12** *Definitions of altered levels of consciousness*

Confusional state: A state in which the patient is bewildered and has difficulty following commands. He is at least mildly disoriented to time. Stimuli are consistently misinterpreted and attention span is shortened. Memory is faulty

Acute organic brain syndrome (delirium): A more florid state in which the patient is sometimes out of contact with the environment and unreachable by the examiner. The patient is disoriented and he tends to be fearful and irritable

Stupor: An unresponsive state from which the patient can be aroused only by vigorous and repeated stimuli

Coma: A state of unarousable unresponsiveness: "the absence of any psychologically understandable response to external stimulus or inner need"

From Plum P, Posner JB. *The Diagnosis of Stupor Coma.* 2nd Ed. Philadelphia, PA: FA Davis Co; 1972, with permission.

TABLE **26.13** *The Glasgow coma scale (GCS)*

Eye opening	
Spontaneous	E4
To speech only	E3
To pain only	E2
None	E1
Best motor response	
Obeying commands	M6
Localizing to pain	M5
Withdraws to pain	M4
Abnormal flexion (decorticate)	M3
Extensor response (decerebrate)	M2
None	M1
Verbal response	
Totally oriented	V5
Confused conversation	V4
Using inappropriate words	V3
Incomprehensible words	V2
None	V1
Total score (3–15)	

From Patten J. *Neurological Differential Diagnosis.* 2nd Ed. London: Springer; 1996, with permission.

A Note on the Head-Injured Patient

Head injury is a very frequent problem. It is the most frequent cause of death in the pediatric population, comprising between 50% and 80% of all trauma-related deaths. The biomechanics of injury are quite complex; assumptions based on an incompletely understood mechanism of injury are treacherous (Ommaya et al., 2002).

Some external signs of head injury are summarized in Chapter 9. Even if the patient is alert, these signs must be heeded. The absence of visible signs does not rule out serious injury, and young children with a subdural hematoma secondary to minor trauma have presented with only irritability and/or vomiting (Jenny et al., 1999).

After stabilizing the head-injured patient from the medical and surgical standpoint (e.g., making sure that the patient does not have a ruptured spleen, tension pneumothorax, hemorrhage from a major fracture, etc.), obtain a neurologic consultation and consider an emergency CT head scan. Remember that a head-injured patient also has a cervical spine injury until proven otherwise; his neck should have been stabilized at the scene by emergency personnel and X-rayed upon initial evaluation and treatment (M. Faria, *personal communication*, 1999).

The signs of rising intracranial pressure (ICP) with the possibility of fatal brain displacements or shifts are rising blood pressure, slowing pulse, and slowing or periodic respiration. This is called the Cushing triad. The signs of concealed internal bleeding and the development of surgical shock are falling blood pressure, rapid thready pulse and rapid respiration (Patten, 1996).

Although initially developed for evaluating patients with severe alterations of consciousness, the GCS is now frequently used in emergency departments for assessing patients with head trauma.

TABLE **26.14** *Some causes of loss of consciousness*

Head trauma
Concussion
Cerebral contusion with cerebral edema
Brainstem contusion
Subdural hematoma
Epidural hematoma
Cerebrovascular accidents
Hemorrhage: cerebral, cerebellar, brainstem
Subarachnoid hemorrhage
Thrombotic or embolic stroke with cerebral edema
Air, fat, or amniotic fluid embolism
Hypoperfusion
Arrhythmias
Cerebrovascular insufficiency (e.g., vertebrobasilar occlusion)
Steal syndromes
Shock
Syncope
Cerebral edema
Malignant hypertension
Hydrocephalus
Basilar artery migraine
Drugs and toxins
Alcohol
Narcotics
Barbiturates and other sedatives
Insulin
Aspirin
Acetaminophen
Carbon monoxide
Methemoglobinemia
Heavy metals (lead, arsenic, mercury, thallium)
Metabolic disturbances
Diabetic ketoacidosis or hyperosmolar coma
Uremia
Hepatic failure
Hypoxemia
Hypercapnia
Severe acidosis
Hypoglycemia
Hypercalcemia
Hyponatremia
Myxedema
Thyroid storm
Hypothermia
Heat stroke
Malignant hyperpyrexia
Adrenal insufficiency
Vitamin B_{12} deficiency
Wernicke encephalopathy (cerebral beriberi)
Alcoholism
Hyperemesis gravidarum

(continued)

TABLE **26.14** *Some causes of loss of consciousness (continued)*

Profound anemia
Infections
Generalized sepsis
Central nervous system infections
Seizures, status epilepticus, or postictal state
Tumor
Brain tumor
Metastatic tumor
Carcinomatous meningitis

A GCS score of 12 or lower and the presence of focal neurologic deficits were significant predictors of an abnormal CT scan (Ng et al., 2002). A GCS score of 15, however, particularly with a history of loss of consciousness, does not rule out significant injury; 26% of patients with radiographic progression of injury had an admission GCS of 15 (Givner et al., 2002). Serial GCS scores should be recorded, as any deterioration is cause for concern. Because of its reliance on language functions, the GCS may be relatively insensitive to right-sided intracranial mass lesions (Dacey et al., 1986). The examiner's sense that the patient just does not seem normal should be heeded even if the GCS score is 15.

Subdural Hematoma

In any case of head trauma, the possibility of a subdural hematoma, possibly manifesting after the patient has been discharged, must be considered. The degree of trauma need not be severe, especially if the patient has predisposing factors such as coagulation abnormalities or osteogenesis imperfecta (Pozzati et al., 1983).

The absence of trauma (or of a history of trauma) does not, of course, rule out a subdural hematoma. Neck trauma alone (whiplash) has rarely been associated with subdural hematoma in adults (see Chapter 25) but is said to cause shaken baby syndrome.

Shaken Baby Syndrome

Many hospitals now post warnings not to shake infants lest serious brain damage or death result. Increasingly, criminal prosecutions are brought in deaths involving the triad of a swollen brain, subdural hematoma, and retinal hemorrhages (see Chapters 9 and 10).

The theory of shaken baby syndrome assumes that subdural and retinal bleeding is the result of criminal abuse unless proved otherwise (Geddes and Plunkett, 2004). The theory has been challenged, and convictions are under appeal.

Defining child abuse on the basis of "subdural hemorrhage and retinal hemorrhage when there is '*no history accounting for patient's serious head injury*'" and then concluding that there is a high incidence of retinal hemorrhage in child abuse" would appear to be a self-fulfilling prophecy (Fung et al., 2002, emphasis in original). Very few confessions are ever extracted (Geddes et al., 2001), and the reliability of the confessions themselves, or of statements about them, for proving a theory of causation has been questioned (Leestma, 2005, 2006). The vast body of literature on child abuse is composed of "anecdotal case

series, case reports, reviews, opinions, and position papers" (Barnes, 2002). By evidence-based medicine criteria, few published reports merit a rating above a class IV (any design where the test is not applied in blinded evaluation, where evidence is provided by expert opinion alone, or in descriptive case series without controls) (Barnes, 2002). The evidence has been compared to an inverted pyramid, "with a very small database (most of it poor quality original research, retrospective in nature, and without appropriate control groups) spreading to a broad body of somewhat divergent opinions" (Donohoe, 2003).

The only experimental verification for the hypothesis of causing subdural hematomas in infants by shaking is a study that used anesthetized rhesus monkeys in simulated rear-end motor-vehicle collisions, the actual point of interest in the experiment. Rotational acceleration exceeding 40,000 radians per square second produced brain injury, without impact. In 11 of the 19 monkeys so injured, there were also pathologically demonstrable neck injuries. The experimenter calculated that the angular acceleration required to produce comparable injury in an adult human should be 6,000 to 7,000 radians per square second, a figure he later revised downward to 4,000 radians per square second. The required force is a biologic constant for neural tissue, which is inversely proportional to the mass of the tissue raised to the power of 2/3. The smaller mass of the infant head should require greater acceleration to cause injury than in an adult, not less (Uscinski, 2002). Human subjects shaking dolls with hinged necks and equivalent massed heads were only able to generate, by shaking alone, mean angular accelerations of 1,138.54 radians per square second, about one fourth of the concussive injury threshold. Impact against a padded or hard surface, on the other hand, could generate a mean acceleration of 52,475.70 radians per square second (Duhaime et al., 1987).

"There is just no conclusive evidence that this entity exists," conclude two forensic pathologists, who believe that head injury ascribed to shaking results from blunt trauma to the head (DiMaio and DiMaio, 2001).

The triad attributed to shaken baby syndrome has a differential diagnosis. Intracranial hemorrhage is surprisingly common in infants. An autopsy series of 50 nontraumatic deaths of infants of age up to 5 months showed fresh intradural hemorrhage in 36 cases (72%). An earlier study had documented intradural bleeding as a "constant feature" in premature infants. Most of the subjects had been profoundly hypoxic before death because of conditions such as bronchopneumonia, congenital heart or lung disease, placental insufficiency, septicemia, and birth asphyxia.

The authors suggest that in the immature brain, hypoxia alone or in combination with infection is sufficient to activate the pathophysiologic cascade that culminates in altered vascular permeability and extravasation of blood within and under the dura. Additional factors include venous hypertension and sustained or episodic arterial hypertension. Retinal hemorrhages can be explained by the same factors (Geddes et al., 2003).

Subdurals can occur in infants as a consequence of normal birth; the true incidence has yet to be determined. Rebleeding into an unrecognized chronic subdural may occur with minimal or no trauma (Uscinski, 2002).

Lesions of the Reticular Activating System

Basilar artery thrombosis, encephalitis, Wernicke encephalopathy, trauma, neoplasm, and other entities capable of producing a bilateral lesion in the upper brainstem can damage the reticular formation and the corticospinal and corticobulbar pathways, producing a syndrome of almost total paralysis and impaired consciousness.

The RAS is necessary for sleep and wakefulness. Drugs may produce unconsciousness primarily through selective depression of the ascending RAS. Dysfunction of the RAS may be involved in schizophrenia, Parkinson disease, narcolepsy, and diverse other disorders involving attention deficits or sleep–wakefulness disorders, as well as comatose states.

Prolonged Comatose States

Coma Vigil

Patients in coma vigil can apparently be awakened by stimuli. The eyes can open and at times sweep the room from side to side or follow moving objects and persons. Because they seem to respond to loud noises, they are said to be "standing vigil." This state is also called *akinetic mutism* to emphasize the absence of movement (except of the eyes) and the patient's silence, but this term does not highlight the peculiar retention of eye movement. There are two other inconstant paradoxes: Although there are no deep tendon reflexes, there sometimes is withdrawal from noxious stimuli; and although such patients cannot chew, they can sometimes swallow. The reflex withdrawal or the eye tracking (giving an "unfulfilled promise of speech") may be interpreted by the patient's family as a sign of recovering awareness. There is often a difference of opinion between family members, who spend hours each day at the bedside, and professionals, who drop by for 10 minutes but whose observations receive theoretical reinforcement from a multidisciplinary task force (Borthwick, 1996).

Damage to parts of the medial frontal lobes is often seen in akinetic mutism (Zeman, 1997). This syndrome must be distinguished from bilateral frontal lobe isolation. It is sometimes distinguished from a "minimally responsive state," into which patients in a vegetative state sometimes emerge. Coma vigil is apparently somewhere along a poorly characterized cognitive continuum between locked-in state and persistent vegetative state (PVS) (Howsepian, 1996).

Persistent Vegetative State

The term "vegetative" means "an organic body capable of growth and development but devoid of sensation and thought." The essence of the state is "the absence of any adaptive response to the external environment, the absence of any evidence of a functioning mind that is either receiving or projecting information, in a patient who has long periods of wakefulness" (Zeman, 1997). A PVS is one that has persisted for longer than a predefined period, usually 1 month. Diagnostic criteria have been defined in a consensus statement by the Multi-Society Task Force on PVS (*N Engl J Med*, 1994a,b).

Patients in this state have apparent sleep–wakefulness cycles. They can be aroused by strong stimuli, and they can respond by quickened breathing, grimacing, or moving their limbs. They can generally breathe without mechanical support. Certain spontaneous actions occur without discernible reason or purpose (chewing, swallowing, shedding tears, screaming, grunting, or smiling). There are usually spontaneous roving movements of the eyes. Brainstem reflexes (pupillary, oculocephalic, gag, and corneal) are usually intact. Limb signs are variable.

Any unambiguous sign of conscious perception or deliberative action is incompatible with the diagnosis. The evidence is easily missed (Zeman, 1997). It has been observed that the cluster of symptoms defined in the consensus statement of the Multi-Society Task Force on PVS could be accounted for by a combination of severe motor apraxia, agnosia, and hypoactive delirium with an intact but significantly altered level of consciousness (Howsepian, 1966). After a period of time, the state may be considered "permanent," and medical care (including feeding and hydration) is sometimes withdrawn by court order or by implementating an "advance directive."

Although recovery from a *permanent* vegetative state is impossible by definition (and certainly unusual), remarkable recoveries from what must have been an incorrect diagnosis of "permanent" vegetative state are described. An exquisitely documented case is that of a 60-year-old linguist, who remained in deep coma for nearly 4 months after open-heart surgery and yet experienced an almost complete recovery, publishing three books and lecturing extensively during the next 5 years (Goshen-Gottstein, 1988). Of adults with PVS 1 month after head trauma, 33% had regained awareness at 3 months, 46% at 6 months, and 52% at 12 months. The outcome was much worse for nontraumatic causes, with only 15% aware at 6 or 12 months after the incident (Zeman, 1997). The incidence of improvement in permanent posttraumatic vegetative state, which has lasted longer than 1 year, is about 14% (Childs and Mercer, 1996). The incidence of incorrect diagnosis of PVS 3 months after trauma has been stated to be as high as 48% (Childs et al., 1993).

Some patients thought to have PVS may actually be in a locked-in state (*vide supra*), as energetic and ingenious efforts to establish communication may show. Contrary to the expectations of many medical students and neurosurgeons, and to public opinion polls of persons who are neurologically intact, such patients may even express a will to live. Queries can be structured in a way that distinguishes meaningful from random response (McMillan, 1996).

PVS is a behavioral, not an etiologic or anatomic, diagnosis. Indeed, the anatomic basis varies considerably; the brain of Karen Ann Quinlan, whose case established a legal precedent, showed relatively selective necrosis of the thalamus, with the cerebral cortex, outside of parasagittal and occipital regions in which extensive lesions do not in themselves cause global deficits in awareness, rather well preserved (Kinney et al., 1994).

The diagnosis of PVS postulates an absence of consciousness, which cannot be directly measured but only deduced. Patients who eventually awaken from PVS or from coma generally do not recall experiences while in that state—although some do (Ostrum, 1994)—but then normal persons frequently do not recall dreams. Results of functional tests (EEG, somatosensory responses, neuroimaging scans, and cerebral blood flow) are quite variable (Howsepian, 1996).

The term "vegetative" has been criticized because of its derogatory connotation.

Although discussion of the philosophic issues concerning PVS is beyond the scope of this text, it is worth mentioning that controversy does exist. Indeed, one author asks, "Would it not be better to abandon the diagnosis of PVS, which is so unreliable medically but gives lawyers a false sense of security?" (Colover, 1997).

Brain Death

Criteria for brain death were first established in the US by a team assembled at Harvard Medical School (Report of the Ad Hoc Committee, 1968); some thought that it was established for the purely utilitarian goals of guarding against legal consequences of discontinuing ventilators and for meeting the needs of organ transplantation programs (Wijdicks, 2003).

In making a determination of brain death so that vital organs can be harvested, the physician should know the cause of the coma and that the cause is irreversible. Confounding factors (drug intoxication, hypothermia, or metabolic or endocrine derangements) must be carefully excluded (Burns and Login, 2002). The total absence of brainstem reflexes must be documented on two occasions, customarily 6 hours apart (Wang et al., 2002). These reflexes include the pupillary light reflex, the corneal reflex, the oculocephalic reflex, calorics, and the cough/gag reflex. If instillation of cold water into the ears causes the eyes to deviate, the patient is not brain dead. Additionally, the patient must be unresponsive and have no cerebral motor responses to painful stimuli.

Although the absence of the pupillary reflex, if necessary ascertained with the help of a magnifying glass, is essential to establish brain death, pupillary size depends on the level of the lesion. Fixed and dilated pupils result from intact sympathetic fibers in the cervical spinal cord. "Midposition" (4 to 6 mm) pupils result from damage to the parasympathetic Edinger–Westphal nucleus in the midbrain. "Pinpoint" pupils occur when pontine damage interrupts descending sympathetic fibers, so that pupil size is determined solely by the Edinger–Westphal nucleus. Because pinpoint pupils imply that this nucleus is functional, their presence is incompatible with the diagnosis of brain death (Morenski et al., 2003).

The apnea test is the final one, after the absence of all brainstem reflexes has been documented. If the patient is not brain dead, an improperly performed test could itself cause further damage or ensure "the fulfillment of the allegedly invariably fatal prognosis attached to the diagnosis of 'brainstem death'" (Evans, 2002). Only about 50% of the protocols in use worldwide recommend apnea testing (Swash and Beresford, 2002).

To perform the apnea test, first document that the patient is not hypoxic (i.e., that the arterial pO_2 is >55 mm Hg). Calculate the apnea time needed to raise the pCO_2 to greater than 60 mm Hg, which should be sufficient to stimulate the respiratory center unless the patient is chronically hypercapneic. Generally, the pCO_2 increases by about 2.5 mm Hg per minute of apnea, thus the apnea time is $(60 - pCO_2)/2.5$. While administering 100% O_2 by continuous positive airway pressure (CPAP), disconnect the ventilator for the requisite time period and obtain a blood gas to show that the pO_2 did not drop below 55 mm Hg and the pCO_2 was greater than 60 mm Hg. If no respiratory effort occurs and the blood gas confirms the adequacy of the test, brain death may be certified. The test must be interrupted and the ventilator reconnected if the patient makes respiratory efforts, if cardiac arrhythmias or hypotension ($BP_{sys} < 90$ mm Hg) occurs, or if pulse oximetry indicates marked desaturation (Wijdicks, 1995).

The protocol varies with the institution and legal jurisdiction; there is no global consensus on diagnostic criteria (Wijdicks, 2002). In particular, the British standard, applied in most former

colonies including India, is brainstem death (Sethi and Sethi, 2003), whereas the standard is whole-brain death in the US, Central and South America, and much of Europe including Germany (Haupt and Höfling, 2002). Additional testing may be required, such as EEG, transcranial Doppler, auditory or somatosensory evoked potentials, radionuclide scans, or angiography (Wijdicks, 1995; Karakatsanis and Tsanakas, 2002). Some say that irreversibility of neuronal damage can be proved only by demonstrating complete absence of intracranial circulation (Bernat, 2004).

Because children may recover after substantially longer periods of unresponsiveness than adults, particular caution is required in applying criteria for brain death in patients under the age of 5 years (Report of the Medical Consultants, 1981).

One should never be in a hurry to make this diagnosis. If uncertain, one can wait and retest. The state known as brain death rarely lasts more than a few days and is always followed by circulatory collapse and systemic death (Byrne and Weaver, 2004); thus, failure to make the diagnosis will not result in prolonged futile life support.

Although the need for donor organs has led to increased pressures to certify brain death expeditiously, scientific and ethical questions remain (Shewmon, 1998; Karakatsanis and Tsanakas, 2002). The legal question of whether someone may be convicted of homicide, if death arguably occurred consequent to removal of the heart or other vital organ, has been raised. Lawyers rarely file charges in cases of brain-dead victims of homicidal assaults until after the victim has been taken to the morgue (Byrne and Weaver, 2004).

Attempts to pass beyond the "dead donor" rule, which is supported by the legal concept of brain death, to the use of organs from persons with "non–fully functioning brains" places the issues in starker relief (Koppelman, 2003).

The term "brain death" was discarded in a 2008 white paper by the President's Council on Bioethics and replaced with "total brain failure," (President's Council, 2008) a philosophically neutral and physiologically clearer term (Shewmon, 2009).

Cognition

If one finds that a patient seems peculiar or uncanny in some poorly defined way, one is required to make further investigation. At the very least, one should do a complete and thorough mental status examination. One should never find one's self describing a patient as "weird" or having "a funny kind of personality" without subsequently making sufficient detailed examination as to be able to elucidate the ultimate nature of such a puzzle. Noting that the patient is odd should be the beginning of a diagnostic move, not its termination.

Other clues to the need for a detailed mental status examination include: (1) apparent lack of cooperation; (2) the physician having to talk slowly, ask directive questions, prompt or redirect the patient, model behavior (such as saying "ahhh"), or having to do things for the patient (such as taking off his glasses for the ophthalmologic examination). Such subtle, easily missed findings are potentially significant signs of cognitive impairment (D. Royall, *personal communication*, 1999).

Dementia

Dementia is a syndrome of acquired intellectual impairment characterized by persistent defects in at least three of five areas: memory; personality or emotional state; language; thought (abstraction, mathematics, judgment); and visual/spatial skills.

The cognitive portion of the mental status examination must be performed before the history is completed in all patients who are suspected of having one of the organic brain syndromes (Table 26.15) or any other cause of disorientation. Accordingly, much of this material has already been covered in Chapter 2 even though it is recorded under "neurologic exam." (Of course, if the patient is not a reliable reporter, that fact should be recorded on the first page of the case report under "reliability"; see Chapter 4.)

Caveats about screening asymptomatic individuals with tests of limited specificity are especially important for a diagnosis like dementia with potentially life-altering consequences. The clinical value of identifying possibly affected individuals must be weighed against possible harm from a stigmatizing label. Also note that mild cognitive impairment, as might be found with the Mini-Mental State Examination (MMSE), is not the same as dementia, although

TABLE **26.15** *Common types of dementia*

Cortical dementia
Alzheimer disease (50%–70%) (Geldmacher and Whitehouse, 1997)
Lewy body dementia
Pick disease (<1%)
Subcortical dementia
Extrapyramidal syndromes
Parkinson disease
Huntington disease
Progressive supranuclear palsy
Wilson disease
Spinocerebellar degeneration
Normal pressure hydrocephalus
Toxic and metabolic encephalopathies
Drug abuse (alcohol, cocaine, etc.)
Systemic illness
Endocrinopathies (thyroid, diabetes, etc.)
Anoxic encephalopathy
Deficiency states (Vitamin B_{12}, folate, iron, etc.)
Drug intoxications
Heavy metal exposure (lead, bismuth, mercury, arsenic)
Binswanger disease (subcortical arteriosclerotic encephalopathy) (Geldmacher and Whitehouse, 1997)
Pseudodementia (depression of the elderly)
Mixed cortical/subcortical dementias
Multi-infarct dementia
Infectious dementias (AIDS, slow virus, kuru, Jakob-Creutzfeld, etc.)
Posttraumatic pugilistic dementia
Brain tumor (primary, metastatic)

From W. Summers (personal communication, 1999), with permission.

it may progress to dementia. The sensitivity and specificity of the MMSE are stated to be 75% and 51%, respectively, for mild cognitive impairment (Ellison, 2008).

Tests of Executive Function

In 1994, the American Psychiatric Association recommended adding tests for executive control functions to the assessment of patients, although this is not widely done (Royall, 2000). Executive control functions (ECF) integrate relatively simple ideas, movements, or actions into goal-directed behavior and are thus important to practical coping ability (Workman et al., 2000).

The only standardized test of executive control functions is the Executive Interview (EXIT25), a 15-minute, 25-item test. In performing the test, the examiner also watches for global features such as perseveration, imitation behavior, intrusions, frontal release signs, lack of spontaneity with a need for prompting, disinhibited behaviors, and utilization behaviors. When performed in a standardized manner, it correlates well with problem behavior and needed level of care (Royall et al., 1992, 1993a,b). As with the MMSE (see Chapter 2), there is a learning effect, so neither is an ideal tool for frequent follow-up.

Other tests have been designed for ease of follow-up, some by telephone with minimally trained personnel. Such tests are needed to assess interventions such as drug therapy (Summers et al., 1990).

A simple, quick examination that lends itself to frequent repetition and many clinical settings is the CLOX, an executive clock-drawing test. For young adult subjects, the mean score on CLOX 1 is 13.2 $\pm$ 1.6 and on CLOX 2, 14.2 $\pm$ 1.2. Results of this test correlate strongly with the EXIT (Royall et al., 1998).

Clock-drawing tasks (CDTs) were initially designed as a test for temporoparietal dysfunction (unilateral spatial neglect) but have been found unreliable for this purpose (Ishiai et al., 1993). However, they do correlate well with a diagnosis of dementia because performance requires visual–spatial orientation, constructional praxis, concentration, language comprehension, numerical knowledge, and planning ability (Mendez et al., 1992). With the MMSE (see Chapter 2) as the standard, the clock-drawing test had a sensitivity of 77% and a specificity of 87% (Death et al., 1993). It was easier to administer to the hearing-impaired and is less threatening to many patients. A longitudinal study also showed that in patients scoring more than 21 points on the MMSE, an abnormal clock-drawing test increased the risk of later development of outright cognitive impairment by a factor of five (Ferrucci et al., 1996).

A Method

1. Provide the patient a piece of paper with a 10-cm circle drawn in heavy black ink with a dot in the middle.
2. Instruct the patient: "Imagine this is a clock face. Please fill in the numbers of the clock face."
3. Repeat the instructions if asked, but give no further instructions. Invite the patient to correct an error if he spontaneously recognizes it and asks to fix it.
4. Score the clocks: bizarre (class 1); major spacing abnormality, but at least 11 of the 12 correct numbers are present with at most one addition or duplication (class 2); all numbers are correct but there are minor spacing abnormalities or there are single number errors but correct spacing (class 3); normal clocks (class 4). Clocks of class 1 and 2 indicate cognitive impairment (Death et al., 1993).

Another Method

1. Draw a circle about 4.5 in. in diameter using a template.
2. Ask the patient to "put the numbers in the face of the clock" and, when that task is completed, to "make the clock say 11 minutes after 11."
3. Place the "12" at the top of the page, and divide the clock into eighths. Score one point for each of the following numbers that falls into the proper eighth: 1, 2, 4, 5, 7, 8, 10, and 11. Score one point for a shorthand pointing at 11 and one for a long hand pointing at 2 (no points if the hands are approximately equal in length).
4. A score of 7 or less indicates cognitive impairment (Manos and Wu, 1994).

Methods that do not provide a circle and involve more complicated scoring are also described (Sunderland et al., 1989; Mendez et al., 1992).

The contribution of the two-part CLOX is to help discriminate executive control of clock drawing from clock drawing itself. Lesions to the frontal system (as in major depression, noncortical dementias, and frontal dementias that spare posterior cortical areas) affect CLOX 1 more than CLOX 2. Interestingly, a significant fraction, nearly 30%, of diabetic outpatients showed impairment, which in the majority was a relatively isolated executive impairment (Royall, 1999)

An Illustrative Interview

An abbreviated transcription of an actual interview with a dementia patient follows. Its purpose is to illustrate some points already covered: the importance of specific testing for orientation; the importance of testing as soon as the confused patient becomes confusing; and the recognition that although this portion of the mental status examination is done while speaking with the patient, it is still part of the physical examination. This particular patient was seen at a time when I was in charge of a psychosomatic service. This was the fifth medical patient in a row who had an organic brain syndrome discovered in a consultation for a "functional" disorder. We were once again falsely assured that the patient was oriented.

In all fairness, and to illuminate the pedagogic difficulty in convincing the very best of young minds that one must specifically test for orientation and not assume that it is present, note the following: The tape recording of this interview has been played for many generations of medical students who could be taught to enjoy the macabre humor of the senior medical resident struggling to get the correct diagnostic information. In later years, one could see these very same medical students have the same experiences in their turn. This may mean that the best way to teach medicine is at the bedside with real patients, rather than by "show and tell."

Doctor: "How are you doing?""
Patient: "All right…."

Doctor: "Having any problems?"
Patient: "(quickly). No …"
Doctor: "You been feeling all right?"
Patient: "Yeh…."
Doctor: "Any complaints?"
Patient: "No…"
Doctor: "Anything bothering you at all.""
Patient: "(quickly). No…"
Doctor: "(20-second pause)…. Do you know where you are?"
Patient: "Yeh (mumbled statement)"
Doctor: "Where are you?"
Patient: "In, uh, Birmingham Hospital."
Doctor: "Which hospital?"
Patient: "The VA? (the correct answer)"
Doctor: "The VA. yuh … And, uh, do you know what day it is?"
Patient: "No."
Doctor: "Do you have any idea what day it is?"
Patient: "No, I don't."
Doctor: "Do you know what month it is?"
Patient: "(mumbles) …Is it Christmas month?"
Doctor: "What month is that?"
Patient: "December."
Doctor: "That's correct … What year is it?"
Patient: "Forty … three … I believe. (It is 1971.)"
Doctor: "Forty-three?"
Patient: "Yeh?"
Doctor: "Is that what you think it is? Forty-three?"
Patient: "Yeh, that's about what I think it is. Nineteen forty-three…"

It may be argued that this patient was so severely disoriented in the dimension of time that he must have had chronic organic brain syndrome (i.e., dementia). It might be argued further that there was very little likelihood of finding a reversible dementia, and thus no point in making the diagnosis. I am unwilling to accept this latter position for three reasons. First, even if the dementia were irreversible, knowing that the patient has impaired cognition helps the doctor understand some of the patient's behavior; it will also help the doctor avoid inappropriate behavior of his own, such as expecting the patient to remember appointments or adhere to medical regimens involving several medications of different schedules. Second, many of the dementias are in fact reversible. And third, the assumption that the problem is irreversible initiates a vicious cycle wherein doctors cease testing for impaired cognition, stop finding most cases, and thus never find reversible dementia even when it is present.

Vascular Dementia

Patients with dementia due to cerebrovascular disease and multiple small infarcts often have neurologic signs, with a median number of 4.5 signs per patient. The most common is reflex asymmetry, found in 49%. Aphasia was found in 41%, dysarthria in 43%, a Babinski sign in 38%, hemimotor dysfunction in 44%, and a variety of other signs in smaller proportions (Staekenborg et al., 2008). If vascular disease can be slowed or reversed, then the progression of this type of dementia might be ameliorated.

Reversible Dementia

A dementia is a chronic (>3 months in duration) impairment of intellectual function manifested by memory, language, visual–spatial skills, emotion or personality, and cognition (abstraction, calculation, judgment, and decision making).

In Table 26.15, the site of the lesion and etiology are used as classification criteria. Note that the frequency of findings adds up to more than 100%. Careful evaluation will often show overlapping causes of dementia. For example, a 70-year-old alcoholic hypertensive patient with a slowly progressive dementia that is AD7C positive, who is on haloperidol 10 mg per day, will have five interacting causes for his confusion: (a) alcoholism; (b) possible hepatic encephalopathy; (c) multi-infarct dementia; (d) Alzheimer disease; and (e) drug intoxication with haloperidol.

Accurate diagnosis is possible in 90% of cases, making the concept of diagnosis only by brain biopsy or autopsy obsolete. The clinical evaluation for dementia is outlined in Table 26.16. If the patient has no focal signs, it is largely an exercise in laboratory medicine and advanced imaging.

A Note on Stimulant Abuse. Functional neuroimaging has revealed a high rate of significant alterations in cocaine users who have normal structural studies. Both metabolic changes and hypoperfusion are implicated. Deficits in executive functioning, memory, attention, and speed of mental processing are often found even after prolonged abstinence and should be specifically sought. Dementia that may become irreversible can be added to the list of other neurologic effects of cocaine, such as seizures, stroke (especially mesencephalic stroke), hemorrhage, and depression (Strickland et al., 1998). Because methylphenidate is chemically similar to cocaine and also blocks dopamine receptors (Vastag, 2001; Gatley et al., 1999), caution is indicated regarding long-term use, as in attention deficit hyperactivity disorder (ADHD) (*vide infra*).

Other Drug Effects. Cholesterol is essential to brain functioning, as in synapse formation and expression of neurotransmitters. The brain contains 25% of the body's nonesterified cholesterol, which is 5- to 10-fold more than is present in other organs. It is biologically plausible that cholesterol-lowering agents, particularly statins, which penetrate the blood–brain barrier, could cause adverse neurologic and psychiatric effects. Depression, confusion, memory loss, and aggressive reactions have been shown to diminish with discontinuaton of such agents and to recur on rechallenge. Even if occurring in a small proportion of treated patients, the reactions may be numerically quite significant, given the large number of patients now being treated (Tatley and Savage, 2007).

Pedagogic Inspiration

Although the workup for reversible dementia in a patient with no focal signs is partly an essay in laboratory medicine (Table 26.16), it might be worthwhile to review the outcome of such evaluations.

A review of 890 dementia evaluations in the modern era revealed that "only" 80% were clearly irreversible (Delaney, 1982; Fox et al., 1975; Freemon, 1976; Garcia et al., 1981; Harrison and Marsden, 1977; Heilman and Wilder, 1971; Larson et al., 1984; Marsden

TABLE

26.16 *Clinical evaluation of the patient with a chronic organic brain syndrome*

A real history and physical examination by a physician
CBC
Thyroid profile with TSH
FTA
HIV antibodies
Blood chemistries:
Glucose, BUN, creatinine, sodium, potassium, bicarbonate, calcium, phosphate, magnesium, ammonia, bilirubin, albumin, alkaline phosphatase, lactate dehydrogenase, aspartate aminotransferase (AST, formerly SGOT), alanine aminotransferase (ALT, formerly SGPT), GGT[a]
Prothrombin time
Thyroxine, T3-resin uptake, and TSH
Folate and vitamin B_{12} levels
EKG
Holter monitor
Cranial MRI
Apolipoprotein-E (APOE) genotyping
Urine AD7C
The "full court press"[b]
Carotid duplex scan
Lumbar puncture (only after a mass lesion such as a brain tumor or subdural hematoma has been excluded; such a lesion could cause herniation of the cerebellar tonsils after an ill-advised lumbar puncture)
Opening pressure
Cells
Sugar, protein, and gamma globulin
AFB, fungal, and bacterial cultures
Serology and counterimmunoelectrophoresis (CIE) for antigens (India ink if cryptococcal antigen not available)
Special CSF tests for Alzheimer disease, especially AD7C-NTP[c]
CT scan with and without contrast
Magnetic resonance angiography
SPECT scan
Digital EEG
RISA cisternography without hydrocephalus (high yield with hydrocephalus and normal pressure)
Ceruloplasmin without Kayser–Fleischner rings
Drug and heavy metal screen

[a]True liver function tests (the bromsulphthalein [BSP] test, indocyanine green, or rose bengal) are no longer done. Portosystemic encephalopathy is extremely unlikely in the presence of a normal serum bilirubin, serum albumin, prothrombin time, and blood ammonia level, and in any case should be apparent on clinical examination.
[b]A phrase coined by Dr Gaeton Lorino of Alabama, a basketball fan, to describe that part of the evaluation done in desperation with little expectation of success.
[c]With the availability of better CSF tests for Alzheimer disease, a lumbar puncture, especially one done with an ultrathin needle under fluoroscopy, may be part of a standard workup. The CSF AD7C-NTP, for Alzheimer disease seventh-column-neurothread protein, is uniquely overproduced by nerve cells affected with Alzheimer disease. If a patient has more than 2 ng/mL of AD7C in the CSF, there is a greater than 90% chance of making the diagnosis of Alzheimer disease at autopsy. Other tests, now in the experimental stage, may soon be available.
CBC, complete blood (cell) count; TSH, thyroid-stimulating hormone; FTA, fluorescent treponemal antibody; HIV, human immunodeficiency virus; BUN, blood urea nitrogen; AST, aspartate aminotransferase; SGOT, serum glutamic-oxaloacetic transaminase; ALT, alanine aminotransferase; SGPT, serum glutamic-pyruvic transaminase; GGT, γ-glutamyl transferase; APOE, apolipoprotein-E; AFB, acid-fast bacillus; RISA, ribosomal intergenic spacer analysis; SPECT, Single photon emission computerized tomography.
From W. Summers (personal communication, 1999).

and Harrison, 1972; Rabins, 1981; Smith et al., 1976; Smith and Kiloh, 1981).

Of 790 cases with etiologies assigned (all of the above except the series of Heilman and Wilder), 7% had depressive pseudodementia. Note that the cognitive changes are quite real, despite the term "pseudodementia." In fact, blood flow patterns similar to those in Alzheimer disease, left-sided neurologic signs, and enlarged ventricles are not uncommon in depression (Stuss and Levine, 1996). Additionally, many Alzheimer patients present with symptoms of depression. Physicians should treat the mood disorder but follow closely for the onset of Alzheimer disease over the next 2 years (W. Summers, *personal communication*, 2004).

Additional psychiatric diagnoses encountered were mania and schizophrenia. Normal pressure hydrocephalus was encountered in 3% of patients, although it is not clear how many of these were still reversible. Drug intoxication was correctly diagnosed and reversed in 2% of patients. In 2% of patients, a resectable brain mass was detected, although some of these were metastatic. Hypothyroidism was found in only 1% of patients, although a surprising number of cases of hyperthyroidism were found. Subdural hematomas were found in 1% of cases. Other entities that individually contributed less than 1% of cases were portosystemic encephalopathy, neurosyphilis, fungal meningitis, and pernicious anemia.

Today, in addition to the 20% of patients with reversible dementias, more than 60% of the irreversible cases can be improved or the natural history altered.

In 2009, five drugs had been approved as effective in Alzheimer disease, including specific anticholinesterase inhibitors (donepezil, galantamine, and rivastigmine), tacrine, and an *N*-methyl-D-aspartate antagonist (memantine). Initially developed in the 1960s as an oral hypoglycemic agent, memantine is thought to act by activating calcium-dependent protein kinases important in facilitating a memory-encoding mechanism. In addition, a number of other agents are believed to be helpful (such as estrogens, anti-inflammatories, steroids, vitamin E, selegiline, phosphatidylcholine, and "antioxidants") (W. Summers, *personal communication*, 1999), and drugs based on other concepts are being explored.

Dietary factors such as "excitotoxins" (aspartame and glutamate) may be contributory, especially when combined with hypoglycemia or magnesium deficiency (Blaylock, 1997). Excessive excitatory neurotransmitters can increase intracellular calcium and trigger a cascade of events ending in cell death. Memantine may have a neuroprotective effect by blocking excessive glutamate activity.

Early detection of neurodegenerative diseases or their risk factors might make it possible to prevent or at least delay the onset of clinical manifestations (DeKosky and Marek, 2003). The apolipoprotein-E epsilon (ε)4 allele is a major risk factor for neurodegenerative conditions, including Alzheimer conditions. It is also an indicator of susceptibility to heavy metal poisoning, probably by impairing excretory mechanisms (Godfrey et al., 2003). Measures to decrease heavy metal exposure could thus be helpful. Nutritional manipulations, especially dietary restriction, are promising (Mattson, 2000; Prolla and Mattson, 2001; Mattson and Chan, 2001).

Further research may produce additional incremental changes, or possibly even a breakthrough as dramatic as the "awakenings" described by Oliver Sacks in hopeless chronic patients with post-encephalitic parkinsonism (Sacks, 1990). Such developments could be foreclosed if dementia is defined as a form of *lebensunwertes Leben* (life unworthy to be lived) and treatment routinely comes to be the withdrawal of "life support" (food and water), as provided in "living wills."

Hallucinations and Delusions

> "*Hallucinations are quite possible in your present condition,*" *the doctor decided,* "*although we should really check on them*…." (Dostoyevsky, *The Brothers Karamazov*, Part 4, Book 11, Chapter 9).

Definitions

Terms for this section are defined in Table 26.17.

Eliciting the History of Hallucinations

It can be very difficult to evoke evidence of a hallucination from the person who has hallucinated. This is especially true when the person does not recognize that he has hallucinated or if he is embarrassed by it.

One way to elicit the information is to ask, "Have you ever had an experience like dreaming, when you were not asleep?" Let the patient attempt an answer without much more structuring of the question. In this way, there is an excellent chance that you will quickly learn about the hallucinations.

Some doctors ask, "Have you ever seen something (or heard something) that other people couldn't see (or hear)?" This question is a little more specific and a bit less sensitive. Of course, the question must be changed for haptic (touch) and olfactory hallucinations.

A Caveat for the Beginner. Scotomata, illusions, "floaters," and figures of speech have all been misrepresented as "visual hallucinations."The use of the suggested questions will increase your batting average in obtaining the history of hallucinations but you should also beware of the false positives.

The most difficult false positive is the auditory illusion. We have all heard noises in the middle of the night that could be misinterpreted as an intruder. The best distinguishing feature is that the

TABLE **26.17** *Definitions*

Illusion: A false perception occurring in response to a sensor/stimulus

Hallucination: A false perception occurring in the absence of a sensory stimulus

Delusion: A firmly held belief not in keeping with the individual's culture or level of education

Examples: If you hear a car backfire, and you believe that it may be a pistol shot, that is an illusion. If you hear a pistol shot when there has been no sound (either of a pistol or of a car backfiring), that is a hallucination. If you hear a pistol shot and believe that it is God firing a pistol at you because you have ordered inappropriate laboratory tests, that is a delusion. (If someone decides he is ordering too many laboratory tests in the absence of an external sensory stimulus, that is called *enlightenment*.)

illusion is accompanied by perplexity and the hallucination is not. (The pseudoperplexity of a patient who reports seeing a dead relative who speaks a puzzling message is perplexity about the content of the hallucination, not its existence. But the perplexity of a sound in the night is this: If it is an intruder, how could he have gotten in through a locked door?)

Orientation has been suggested as a requirement for hallucinations but should not be used as such. Hallucinating patients with affective disorder or schizophrenia may or may not be disoriented at the time they hallucinate, and patients with organic brain syndrome who hallucinate will definitely be disoriented. This raises the question of the differential diagnosis of hallucinations, which includes primary affective disorder (depression and mania), schizophrenia, alcoholism, hysteria, and organic brain syndromes. No type of hallucination is diagnostic for any disease (Goodwin et al., 1971).

Delusions

As implied by the definition (Table 26.17), a belief that is delusional for one person might not be so for another.

For example, believing that departed relatives inhabit environmental flora would be appropriate for adherents to an animist religion but inappropriate for a Catholic bishop whose culture and education advise him that the souls of the departed are somewhere else.

A delusion must also meet the criterion of being firmly held, which means that the person adheres to it in the face of reasonable contradictory information or when adherence to the belief poses a real threat to the believer.

Note that both criteria must be satisfied. Religious beliefs that are in keeping with the group religious belief are not classified as delusions, even when so firmly held as to lead to martyrdom, because there is no available evidence that can be used as "reasonable contradictory information." Martyrdom per se would be considered evidence of delusional behavior only if it occurred because of a religion to which the party was the sole adherent. Nevertheless, it is possible to diagnose delusional behavior in a religious setting. For example, three charwomen were members of a fundamentalist church that held all-day Sunday services. At these services, the women regularly wore special robes and as part of the religious event engaged in a musical activity during which they had an ecstatic spiritual experience. For this group, this experience represented transport to the presence of the deity. One particular Sunday, one of these women refused to remove her robes at the end of the service. She continued singing and communing with the deity throughout the night, until the next day, when the other two women correctly brought her to the emergency room. Thus, what is "in keeping with the individual's culture" on one day might not be on the next day.

Similarly, a belief about health matters that would not be delusional for an uneducated person might be delusional if held by a physician. The second criterion ("firmly held") is decisive here.

Scientific hypotheses are beliefs to which there may be tenacious adherence. But until contradictory evidence appears, adherence to a hypothesis (no matter how bizarre) is not delusional. Even adherence to disproved hypotheses may, on further inquiry, turn out to represent narcissism rather than delusion.

Self-test: *Which, if any, of the following are evidence of delusional thinking?*

1. A man caring for a demented wife came to believe that the electricity and telephone lines coming into his home were poisoning him, so he cut them down. He also believed that the water lines and gas lines were sucking his money out of the house, so he had those services disconnected. In this state, he and his wife perished during inclement weather.
2. A patient reported that on awakening from sleep, he believed he saw an elephant in his bedroom. When he gasped aloud, the startled elephant turned into a lion and vanished upward through the ceiling.
3. Regardless of weather, a woman stands in front of a television store window for hours because the television sets are showing her private messages (concerning her role in an earlier life), which are being sent to her by the head of the Central Intelligence Agency.
4. A man believed that his country's legal system existed for the purpose of providing social stability for an economic system that the man believed to be unfair and inefficient. In order to bring his beliefs to a wider audience, he engaged in public protests against the economic system, which led to his incarceration.

Write your answers down. Now go back and look at the definitions at the top of this section. Reread your answers. Do you want to change any of them? The correct answers are found in Appendix 26.4.

While these examples refer to persons who brought themselves to the attention of others, there are many persons who have delusions but who do not present them so openly. Sometimes this is because the delusion, although firmly held, does not in any way intrude into their social intercourse. Some delusional patients have learned to conceal the delusion from examiners until assured of a hospitable reception. The following sequence of questions may be useful for eliciting delusions in such cases (and for performing this part of the mental status examination in all patients on whom it is to be done).

1. "Do you have some opinions that are not held by other people?" (Most people believe they do.) "Could you tell me about them?" Or, "Could you tell me about some of them?" Or, "Could you tell me about some of the more interesting ones?"
2. "Do you have any special abilities?" (Most people believe they do.) Or, "Do you have any special skills?" Or, "Can you discern things other people cannot?" Or, "Can you pick up on messages that other people might not?" Or, "Do you ever get special messages in public?" Or, "Do you ever get special messages from loudspeakers?" Or, "Are there ever special messages for you on the radio (on television, in the newspaper, in musical songs, crossword puzzles, etc.)?"
3. "Do other people ever try to influence how you think?" (Politicians always do.) Or, "How do they do this?" Or, "Who are they?" Or, "What do they want?" Or, "Do they ever try to influence your behavior?" (Advertisers do.) Or, "How do they go about it?"

Each of the above sets is arranged in order from open-ended, vague, nonthreatening questions (which will elicit a lot of false positives) descending to more diagnostic ones. With much practice, careful attention to the patient during the interview will permit the examiner to move quickly through this portion of the examination.

However, the most important aspect of this examination is the physician's unspoken thoughts about the meaning of delusions because these thoughts will color his demeanor and influence his nonverbal and verbal signals to the patient. Thus the doctor's thoughts may influence the patient's answers to the doctor's questions.

This is known as the "experimenter effect" in experimental psychology. That is, the experimenter, without realizing it, gives a subtle cue to the subject and gets a predetermined response. This chapter of epistemology began with the performing horse Clever Hans, which could answer, by tapping on the stage, very complicated arithmetic and geographic questions. Collusion was suspected because Clever Hans could answer correctly only those questions to which the owner knew the answer. But the owner cooperated for years in all studies of the phenomenon and he was as surprised as anyone when he was finally shown photographs revealing that he slightly changed the inclination of his head when Clever Hans had tapped a sufficient number of times. Clever Hans was reading a subtle nonverbal signal (Rosenthal, 1966).

Differential Diagnosis of Delusions

Delusional thinking is often found in schizophrenia and the schizophreniform disorders, the latter including, but not being limited to, paranoia, amphetamine psychosis, and hallucinogenic psychosis. Delusional thinking may also be seen in the patient with mania, severe depression, and a severe organic brain syndrome. Of these, it is most common in the last, when it is acute. It can also be acute in the affective disorders but this is rarely a diagnostic challenge because mania is easily diagnosed on other grounds, and depression so severe as to be accompanied by a delusion will have probably already brought the patient to medical attention. Hallucinations, with agitation, confusion, and abnormal behavior may occur in attacks of acute intermittent porphyria. Such attacks may have affected the character of George III and the creative genius of Vincent van Gogh. These are almost universally preceded by severe abdominal pain, may progress to a motor neuropathy, and may also involve sensory changes (Elder et al., 1997).

Paranoid Ideation

Technically, paranoid ideation is characterized by persecutory thoughts and feelings that are not subject to modification by logic or experience ("strongly held," in psychiatric terms). The most frequent type of paranoid ideation seen on a general medical ward is ideas of reference. These are the continual impression that the conversation, facial expressions, and behavior of other persons have reference to one's self. (These "other persons" need not be present in fact but may be viewed on a television set. They may be true historic persons such as the director of the FBI or the president.)

Paranoid ideation may be part of several different syndromes:

1. *Paranoid schizophrenia*. In cases of paranoid schizophrenia, patients may fulfill the research diagnostic criteria for schizophrenia (Table 26.18). It should be noted that "paranoid schizophrenia" as a label is one of the most common incorrect working diagnoses extant (*vide infra*, "suspiciousness").
2. *Acute organic brain syndrome, or even dementia, with a paranoid component*. Acute organic brain syndrome is probably the most frequent etiology of paranoid ideation on a general medical service, especially in patients with partial sensory deprivation, such as those who are deaf, blind, immobilized, or in isolation.
3. *Paranoid states*. These are extremely rare. Some such patients may be developing paranoid schizophrenia or may have misdiagnosed delirium. However, most of them have a pure paranoid state, called *paraphrenia* by the British. It can be diagnosed from the fact that the delusional and/or hallucinatory system is confined to one area and there is no other affective, cognitive, or thought disorder.
4. Finally, some patients who are labeled "paranoid" are in fact merely frightened and suspicious and do not have true paranoid ideation. (These are the ones commonly mislabeled as "paranoid schizophrenia.")

In a university psychiatric unit, 40% of all patients admitted during a 10-month period had some sort of paranoid symptoms, ranging from true paranoid delusions down to ideas of reference or simple suspiciousness (Freedman and Schwab, 1978).

Of the patients with paranoid symptoms, 42% had only suspiciousness or ideas of reference. Of the others with true paranoid delusions, only 50% had paranoid schizophrenia. The rest had organic brain disorders or the affective disorders (depression or

TABLE **26.18** *Research diagnostic criteria for the diagnosis of schizophrenia*

A through C are all required

A. Both of the following are necessary:
   1. A chronic illness with at least 6 months of symptoms prior to the index evaluation without return to the premorbid level of psychosocial adjustment
   2. Absence of a period of depressive or manic symptoms sufficient to qualify for affective disorder or possible affective disorder

B. The patient must have at least one of the following:
   1. Delusions or hallucinations without significant perplexity or disorientation associated with them
   2. Verbal production that makes communication difficult because of a lack of logical or understandable organization (This must be distinguished from aphasia; see text)
   Many patients with schizophrenia have a detached affect; however, when it occurs in mild form, interrater agreement is difficult to achieve. On the basis of presently available information, blunted affect probably occurs rarely or not at all in the absence of B-1 or B-2.

C. At least three of the following manifestations must be present for a diagnosis of "definite" schizophrenia and two for a diagnosis of "probable" schizophrenia:
   1. Single
   2. Poor premorbid social adjustment or work history
   3. Family history of schizophrenia
   4. Absence of alcoholism or drug abuse within 1 year of onset of psychosis
   5. Onset of illness prior to age 40

From Feighner JP, Robins E, Guze SB, et al. Diagnostic criteria for use in psychiatric research. *Arch Gen Psychiatry*. 1972;26:57–63, with permission.

mania). Three of the latter patients were inadequately treated for their affective disorders because the presence of paranoid symptoms had led to an incorrect diagnosis of schizophrenia.

Diagnosing Schizophrenia

Criteria for the diagnosis of schizophrenia are given in Table 26.18.

For the Attending. In this section, the Research Diagnostic Criteria for psychiatric disorders is used, not those in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-III or DSM-IV). Although the criteria are similar, there are a number of differences. My preference for the former is based upon long familiarity with them. Also, much psychopharmacology research used these criteria in defining study populations.

There are two drawbacks to the use of these criteria. First, there is a de-emphasis on the individual patient's developmental history, without which it becomes impossible for the physician to understand such issues as noncompliance, the patient's responses to hospitalization or disease, modification of the illness by the patient's social situation, and other items that are impossible to teach from a book but are of overwhelming importance in the actual practice of medicine. (As Hippocrates said, "It is more important to know what kind of patient has the disease, than what kind of disease the patient has.") Of course, there is no reason why a modern physician should have to choose only one of the two.

Second, with the rigid Research Diagnostic Criteria, one finds that the most common psychiatric diagnosis made is that of an undefined psychiatric disorder, and the originators of the system are very proud of this fact as a demonstration that their system is really pulling out "pure cultures" of the disease as it were. This is not true with the DSM-IV (American Psychiatric Association, 1994), which has a diagnosis (or diagnoses) for almost everyone who comes to the psychiatric department, of which diagnoses not all have been subjected to the same rigorous scientific evaluation as the Research Diagnostic Criteria. However, the individual attending can select his own criteria, or even no criteria.

Schizophrenics suffer impairments in executive control function (*vide supra*), as do demented patients. Performance on tests of executive control function and frontal neuroimaging explain more variance in longitudinal functional outcomes than does the successful reduction of psychotic symptoms (Royall, 2000).

One set of criteria that many find useful is Bleulers four *A*'s of schizophrenia: looseness of associations (loss of contact with reality); autism (withdrawal from reality and a preference for fantasy); abnormal affect; and ambivalence. To these, auditory hallucinations, a very common manifestation in schizophrenia, may be added (M. Faria, *personal communication*, 1998).

Confounding Cases

The life of Joan of Arc, a "spectacularly different individual" who apparently experienced auditory and visual hallucinations, has been analyzed by the criteria in DSM-III without arriving at a definite diagnosis (Henker, 1984). The exercise provides a review of the diagnostic criteria for schizophrenia, bipolar disorder, and personality disorders. It also shows the limitations of conventional scientific conceptualizations. Other examples can be cited (e.g., St Paul, Isaiah, Moses, Augustine) of persons who led extraordinarily productive lives, with a profound and enduring effect on the world, while exhibiting behavior that might come to psychiatric attention today (Wilson, 1984).

Other Troubling Thoughts and Behavior

Delusions are to be distinguished from obsessions. Obsessions are troubling thoughts (not actions) that may dominate thinking and that cannot be excluded upon the wish of the patient. A phobia is a morbid fear of some object or situation; the patient usually recognizes an irrational aspect to the fear but still cannot overcome it volitionally. A compulsion is an irresistible urge to perform some act (not a thought) despite the patient's realization that the performance of the act cannot be rationally understood.

For Example: If one had a morbid fear of open places, one would have the phobia called *agoraphobia*. If one could not stop thinking of the word "agoraphobia," one would have an obsession. And if one could not eat breakfast without first writing the word "agoraphobia" 100 times, one would have a compulsion.

Asking About Phobias

Open-ended questions that are useful for eliciting clues to phobias are, "What kind of situations do you dislike?" and "What kinds of things do *you* like to avoid?" The answers are not always about phobias and sometimes even the patient with phobias will need a little encouragement to talk, not yet believing that any of his doctors really want to hear about *that*. But if these questions are asked with a warm genuine interest (and not monotonously as items on a printed questionnaire), one will get leads to phobias if they exist.

To determine whether one is hearing about a phobia and not simply a nonneurotic fear, the trick is to get the patient talking and to *let* the patient keep talking. The patient's fearful affect and the web of detail and inhibition revealed will let the sensitive listener know that he is hearing about things that are truly disturbing to the patient.

The phobia is entirely ego-alien. A normal fearful response is neither ego-alien nor ego-syntonic (see Chapter 2), but always a response to a circumstance (e.g., fear of surgery). If a patient fearful of surgery is given a nonsurgical alternative treatment, the fearful response disappears. But a phobic patient is keenly aware of his phobia even when not in the presence of the feared situation or object. Merely looking at a picture of a phobic object, or thinking of the phobic circumstance, may be noxious.

Affect Disorders

> *I have reigned over 50 years in victory and peace, beloved by my subjects, dreaded by my enemies, respected by my allies. Riches and honors, powers and pleasures have waited on my call. Nor does any earthly blessing appear to have been wanting in my years. During this life of wonder I have kept count of the days of happiness which have been given to me. They number fourteen. O, man, place not thy confidence in this world.* (Caliph Abdar-Rahman III, found postmortem in his private prayer room.)

Depressed Affect

A depressed affect is a predominant and persistent mood tone of sadness, despondency, and/or despair (see epigram). It is a major diagnostic clue to depression and to the *normal* process of grief and mourning when it occurs coincidental with and/or following the real or perceived or expected loss of a significant other or significant personal function. Thus, the loss can be wife, mother, arm, motor function

of the arm, expectation of continued life, independence of lifestyle, sexual ability, or a combination of these or similar functions or ego objects.

Besides, in grief and mourning and endogenous depression, a depressed affect can also occur in characterologic (neurotic) depression, in drug-induced depression, and in the depression associated with occult neoplasms, especially of the abdominal viscera.

Even grief reactions can be pathologic, as in anticipatory pathologic grief. Here, a characterologic (personal) neurotic conflict is activated during the grief reaction toward the imminent death of some significant other. The significant other is usually a person with whom the patient's relationship solved a preexisting neurotic conflict, a conflict that then reemerges with the death of the significant other (Viederman, 1987).

To make a diagnosis of endogenous depression, both of the following criteria are required:

1. Dysphoric mood characterized by symptoms such as the following: depressed, sad, blue, despondent, hopeless, "down in the dumps," irritable, fearful, worried, or discouraged.
2. At least five of the following criteria for "definite" depression or four for "probable" depression: (a) poor appetite or weight loss (positive if 2 lb a week or 10 lb or more a year when not dieting), (b) sleep difficulty (include insomnia or hypersomnia), (c) loss of energy (e.g., fatigabilily, tiredness), (d) agitation or retardation, (e) loss of interest in usual activities or decrease in sexual drive, (f) feelings of self-reproach or guilt (either may be delusional), (g) complaints of or actually diminished ability to think or concentrate, such as slow thinking or mixed-up thoughts, (h) recurrent thoughts of death or suicide, including thoughts of wishing to be dead (Feighner et al., 1972).

Elevated Affect

A predominant and persistent mood tone of euphoria, characterized by an optimistic mental set and feeling of well-being and confidence, inappropriate to the subject and/or circumstances, is a major diagnostic clue to mania.

To make a diagnosis of mania (Woodruff et al., 1971), all of the following symptoms are required (numbers in parentheses indicate the percentage of untreated manic patients who have this symptom or sign at some time during their illness):

1. Euphoria (90%) or irritability (100%)
2. At least three of the following categories: (a) hyperactivity (100%) or increased sexual activity (80%); (b) push of speech (pressure to keep talking) (100%); (c) flight of ideas (racing thoughts) (70%); (d) grandiosity, which may be delusional (100%); (e) decreased sleep (100%); (f) distractibility (70%)
3. A psychiatric illness lasting at least 2 weeks with no preexisting psychiatric conditions such as schizophrenia, anxiety neurosis, phobic neurosis, obsessive–compulsive neurosis, hysteria, alcoholism, drug dependency, antisocial personality, ego-alien homosexuality or other sexual deviations, mental retardation, or organic brain syndrome (Feighner et al., 1972)

Inappropriate Affect

An inappropriate affect is an apparent mood tone that is discordant with what would be expected in the company of the patient's verbal productions. For example, the patient might appear happy when discussing sad things or sad when discussing joyous things. This may be a diagnostic clue to schizophrenia.

Detached Affect

This type of affect is also called *flat*, *blunted*, or *inadequate*. The patient is emotionally dull and detached and appears insensitive to stimuli in an environment that normally causes pleasure, pain, or some other emotion that has observable accompanying manifestations. This is seen in some cases of schizophrenia and depression, *inter alia*.

Assessment of Affect

A Method

1. Listen to the patient's speech. Does he sound depressed, joyful, frightened, detached, or none of the above?
2. Watch the patient's face. Does he appear depressed, joyful, frightened, detached, or none of the above? (Remember that patients with parkinsonism may not have facial expression.)
3. Pay attention to the way that *you* feel. Does speaking with the patient make you feel depressed, happy, or frightened?
4. Is any of the above discordant with the subject or content of the patient's speech? Why?

Interpretation. As a rule, concordance between the estimated affect of any two of the above dimensions suggests that a significant affective diagnosis is possible. For instance, depressed patients tend to look and sound depressed; they may also make the physician feel depressed "for no special reason." Manic patients in their euphoric phase tend to be joyous or excited in their speech and joyous in their appearance, and they tend to make the physician feel happy in the sense of being amused.

Discordance between the verbal output and the simultaneous affect may suggest either an inappropriate affect or an inadequate affect. A special maneuver is useful for the latter: Ask the patient to describe both the happiest and saddest memories of his life. If he consistently maintains an unchanged affect while recalling these experiences vividly, he is likely to have a detached affect.

Affect may not always permit a specific diagnosis. If a patient looks or sounds frightened, this is rather a diagnostic cue to evaluate the cause of the fear, which may be rationally related to the experience of hospitalization or illness. Similarly, a patient may episodically appear detached either because of depression, organic brain syndrome, or simply momentary exhaustion from his illness.

Self-assessment Test: Describe the affect of the following two patients, and write your answer down before consulting Appendix 26.5.

1. A woman tells her doctor that she fears her husband is going to kill their children. While telling him this, she giggles with barely contained glee.
2. A young woman was elected president of her sorority. Two days later, both of her parents were killed in an automobile accident. While describing these events to the physician, she neither smiles, frowns, nor shows any other facial expression of emotion, speaking in a monotonous way without accenting any words.

Hysteria

There are at least six major uses of the word hysteria (Ford, 1983) (Fig. 26-35):

1. Conversion reaction
2. Somatization disorder (Briquet syndrome)
3. Description of a histrionic personality
4. A contagious group process (e.g., an epidemic of hysterical fainting or the reaction of the crowd when the Beatles appeared)
5. As a pejorative term: "another male hysteric"
6. As a specific term within psychoanalytic theory

In the present work, we will confine ourselves mostly to the first three definitions.

A conversion reaction implies the existence of an unconscious conflict that is converted into a bodily symptom or neurologic sign of symbolic meaning to the patient. Supposedly, the conflict would be noxious to the conscious mind, so its expression in body language is adaptive.

A less psychoanalytically derived definition would emphasize the appearance of neurologic signs and symptoms of no known anatomic explanation and so would also include some examples of malingering and "compensation neurosis."

Somatization disorder may be diagnosed by the criteria in Table 26.19. More concise criteria are set forth in the DSM-IV.

Histrionic personality may be diagnosed by the DSM-IV or, in some clinics, by the Minnesota Multiphasic Personality Inventory (MMPI).

Note that a conversion reaction or conversion symptom can be part of the criteria for somatization disorder but each can occur without the other. Similarly, the concurrence of a conversion reaction and hysterical personality was 9%, less than 50%, and more than 50% in three different studies (Ford, 1983).

In the office of Dr Harold Klawans, one could see a photograph of a woman diagnosed as hysterical in 1893 by the English neurologist Purvis-Stuart. She has safety pins through both breasts to show her lack of pain sensation and a "hysterical contracture" of the left hand. Noting that the left arm is also shorter than the right. Dr Klawans made the retrospective diagnosis of syringomyelia, of onset before growth was complete. "What illnesses do we still miss because no one has described them?" he asked (Klawans, 1988).

There is also what Herbert Spiegel has termed a "hysterical response to hysteria," which helps to perpetuate "mini-epidemics" in which bizarre symptoms are transmitted person to person by words and example. The most famous American epidemic was the late 17th-century Salem witch trials, in which 20 persons were executed and hundreds imprisoned. The beginnning of the end occurred when witnesses, crossing a bridge into Ipswich, accused an old woman they encountered of torturing them, and fell into fits of screaming and twisting. Bystanders simply ignored the girls. Another epidemic, of convulsive contortions, occurred on the service of the great neurologist Charcot (Fig. 26-35). It was one of Charcot's most distinguished students, Joseph Babinski, who began to suspect that the symptoms were not the result of a brain condition, but rather were suggested by the examinations to which the patients were repeatedly subjected. Charcot died before he could complete his reassessment of the condition, but did observe that patients improved when isolated from others with similar symptoms. The wards emptied out when his successor simply withdrew attention to the patients he regarded as "counterfeit" (McHugh, 2008).

Drug Abuse (Including Alcohol)

Any one of the following is said to be diagnostic for drug abuse (Feighner et al., 1972), which is discussed in detail in Chapters 2 and 3, but take care not to confuse addiction with dependence on opioids prescribed for chronic pain:

1. History of withdrawal symptoms
2. Hospitalization for drug abuse or its complications
3. Indiscriminate prolonged use of central nervous system active drugs

For alcoholism specifically, two questions are useful: "Have you ever had a drinking problem?" and "When was your last drink?" If the answers are "yes" and "within the last 24 hours," the sensitivity for

Figure 26-35 Grand rounds with Charcot, who is demonstrating the hysterical arc de cercle. Note the large painting of the arc de cercle at the rear of the auditorium in full view of the patient. Could this have been used to help the suggestible discern what was expected? (*Self-test*: In which sense is the word "hysterical" being used? Write your answer down before consulting Appendix 26.6.) (Courtesy of the National Library of Medicine, with permission.)

TABLE **26.19** *Perley–Guze criteria for the diagnosis of hysteria (somatization disorder)*

1. Complicated or dramatic history with onset prior to the age of 35
2. Minimum of 25 symptoms in at least 9 of the 10 symptom groups with no known medical explanation

Group 1
Headaches
Sickly most of life
Group 2
Blindness
Paralysis
Anesthesia
Aphonia
Fits or convulsions
Unconsciousness
Amnesia
Hallucinations
Urinary retention
Ataxia
Other conversion symptoms
Group 3
Fatigue
Lump in throat
Fainting spells
Visual blurring
Weakness
Dysuria
Group 4
Breathing difficulty
Palpitation
Anxiety attacks
Chest pain
Dizziness
Group 5
Anorexia
Weight loss
Marked weight fluctuations
Nausea
Abdominal bloating
Food intolerances
Diarrhea
Constipation
Group 6
Abdominal pain
Vomiting
Group 7
Dysmenorrhea
Menstrual irregularity
Amenorrhea
Excessive bleeding
Group 8
Sexual indifference
Frigidity

(continued)

TABLE **26.19** *Perley–Guze criteria for the diagnosis of hysteria (somatization disorder) (continued)*

Dyspareunia
Other sexual difficulties
Vomiting during 9 months of pregnancy or hospitalized for hyperemesis gravidarum
Group 9
Back pain
Joint pain
Extremity pain
Burning pains of the sexual organs, mouth, or rectum
Other bodily pains
Group 10
Nervousness
Fears
Depressed feelings
Need to quit working or inability to carry on regular duties because of feeling sick
Crying easily
Feeling life is hopeless
Thinking a good deal about dying
Wanting to die
Thinking of suicide
Suicide attempts

From Perley MJ, Guze SB. Hysteria—the stability and usefulness of clinical criteria: A quantitative study based on a follow-up period of 6–8 years in 39 patients. *N Engl J Med.* 1962;266:421–426, with permission.

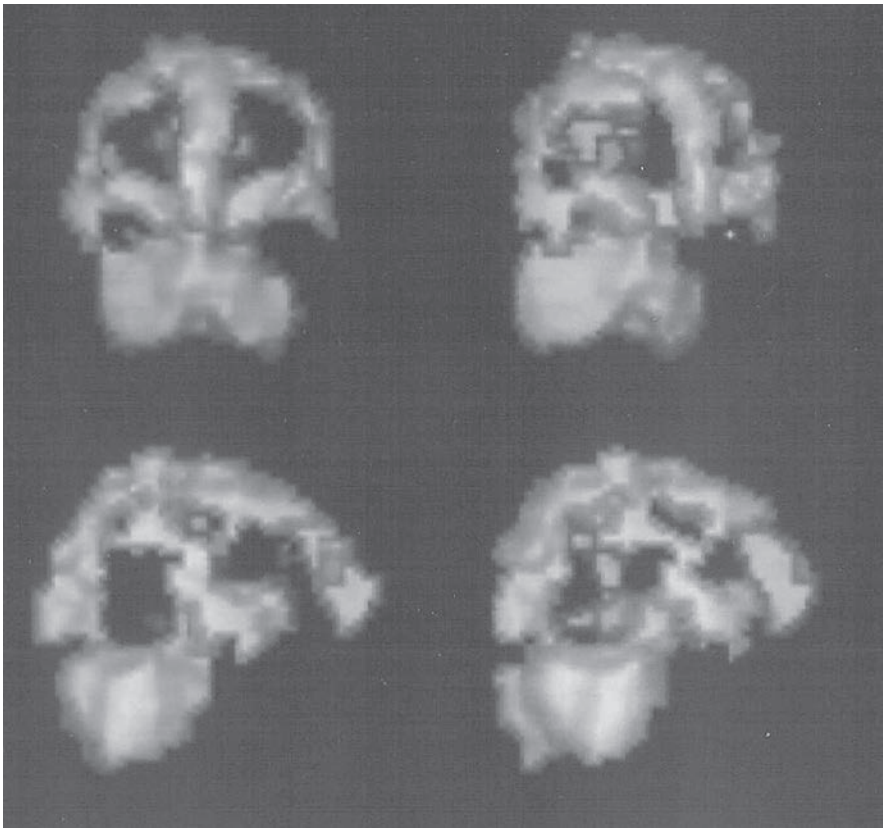
the diagnosis of alcoholism (using the MAST, Michigan Alcoholism Screening Test, as a gold standard) is 92% (Cyr and Wartman, 1988). (A brief version of the MAST is presented in Appendix 26.7. The CAGE and AUDIT tests are discussed in Chapter 2.)

Attention Deficit Hyperactivity Disorder

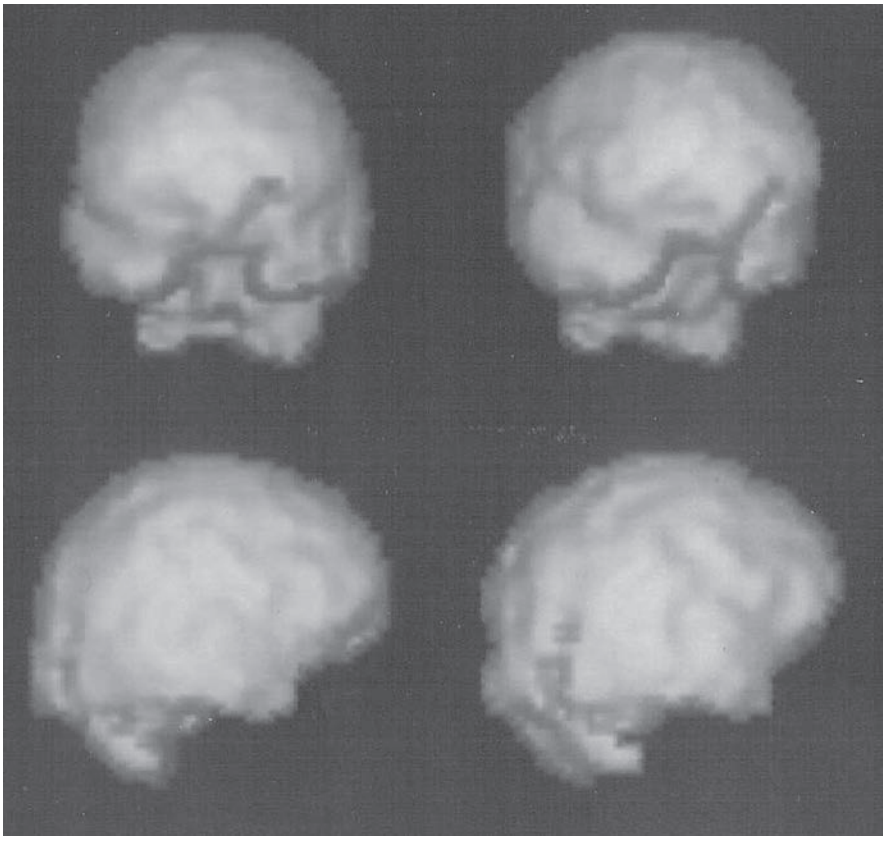
The name "attention deficit disorder" was first used in 1980 to describe a syndrome of behavior that was called "minimal brain dysfunction or damage" in the 1960s. In the 1940s and 1950s, similar behaviors were attributed to brain damage associated with encephalitis (Wolraich and Baumgaertel, 1997).

It is said that 3% to 5% (Barbaresi, 1996), 3% to 10% (Shea et al., 1996), or even 16% (Wolraich et al., 1998) of school-age children suffer from attention deficit hyperactivity disorder, the "diagnosis for the 1990s" (Buncher, 1996), and that the disorder often continues into adulthood. In 1994, more than 8.5 tonnes of methylphenidate (Ritalin) were being produced worldwide, of which about 90% was prescribed for American children, adolescents, and adults. As of 1995, more than 2 million persons had this diagnosis, which is made four to nine times more commonly in boys, and 10% to 12% of American boys between the ages of 6 and 14 were using methylphenidate (Roberts, 1996). The diagnosis is often suggested by school teachers or school psychologists.

ADHD is a set of symptoms: The classic triad is inattentiveness, hyperactivity, and impulsivity. Diagnostic criteria—the presence of a certain number of behavioral manifestations from a checklist—are



A



B

FIGURE 26-36 **A:** Pretreatment single photon-emission computerized tomography (SPECT) scan of a 37-year-old man with human immunodeficiency virus (HIV) encephalopathy for 1 year. He needed a wheelchair, had uncontrollable tremors, and was unable to speak. **B:** After hyperbaric oxygenation, improved SPECT scan correlated with clinical status. The patient was able to walk and speak, and his tremors had stopped. (Scans courtesy of Dr Richard Neubauer, with permission.)

delineated in the DSM-IV. This assessment is purely subjective, although measures are said to have high inter-rater reliability and good face validity (Goldman et al., 1998). There is no definitive diagnostic test (Barbaresi, 1996) and no specific findings on physical examination. Quantitative tests (the Continuous Performance Test and the Matching Familiar Figures Tests) have shown sensitivity and specificity not much better than 75% (Inoue et al., 1998), although increased motor activity ("fidgeting") can be quantitatively demonstrated (Teicher et al., 1996).

ADHD is said to have a biologic substrate, with evidence of brain dysfunction on functional MRI, quantitative electroencephalography, and positron-emission tomography, and a polygenetic mode of inheritance (Kewley, 1998). There is a high incidence of ADHD in children with Gilles de la Tourette syndrome (Barbaresi, 1996).

ADHD symptoms are normally distributed in the population, with an arbitrary level being designated as pathologic (Jureidini, 1996). The signs that may, in their most severe expression, characterize a serious disorder in neurotransmitter function will usually, in their milder expression, characterize normal development. The fact that money may flow into schools and school-based clinics on the basis of numbers of children with this diagnosis has contributed to the development of a medical, social, and educational subculture of ADHD. Diagnoses may be made, nearly exclusively, to meet payers' requirements (Palmeri, 1996), or at least an element of bias is introduced. Thus, it is exceptionally important for a physician who has a relationship with the individual patient and his family to bring an independent, authoritative perspective on this diagnosis.

The differential diagnosis of ADHD symptoms includes sensory deficit, receptive language disorder, other specific learning disorders, seizures, posttraumatic encephalopathy, chronic lead poisoning, untreated phenylketonuria, postinfectious encephalopathy, fetal alcohol syndrome, drug effects, emotional problems, oppositional defiant and conduct disorder, parent–child interaction problems, and mental retardation (Barbaresi, 1996; Wolraich and Baumgaertel, 1997). Some cases may be caused by a hereditary monoamine oxidase deficiency (Cheung and Earl, 2001). Some believe that the school situation (such as boredom, cognitive dissonance, chaotic surroundings, or ineffective instructional methods) or food intolerances may play a role (T. Dorman, *personal communication*, 1999). Some observe that certain children with the diagnosis of ADHD seem to be markedly worse after ingesting food containing excitotoxins such as aspartame (R. Blaylock, *personal communication*, 1999). Others suggest a role for nutritional deficiencies, including magnesium (Starobrat-Hermelin and Kozielec, 1997) and omega-3 fatty acids (Ottoboni and Ottoboni, 2003).

The physician should take a careful history and make meticulous observations, remembering the enjoinder of Hippocrates that the physician should strive to know "what man is in relation to the articles of food and drink, and to his other occupations, and what are the effects of each of them to every one" (Hippocrates, *On Ancient Medicine*, 20). A sleep history is also very important (see Chapter 3).

Functional Imaging in Encephalopathy

Many patients with grossly abnormal cognitive functioning and neurologic examination may show normal or nearly normal anatomy on CT scan or MRI. Single photon-emission computerized tomography (SPECT scan), sometimes called "the poor man's PET scan (positron-emission tomography)," shows radionuclide uptake as a measure of blood flow and cellular metabolism. This technology can be used to follow patients undergoing interventions such as hyperbaric oxygenation (Fig. 26-36).

A Coda on the Patient with a Chronic Neurologic Illness

The modern concept of personhood is intimately associated with brain function. The judgment of "*lebensunwertes Leben*" is much more likely to be rendered for a patient who is no longer "neurologically intact" than for a patient with other types of organ failure. The diagnosis of a chronic degenerative neurologic disease should never be made precipitously, for it will have a far-reaching effect on a patient and all significant others. Beware lest a dismal prognosis becomes a self-fulfilling prophecy.

Individual patients do not always follow the predicted course, particularly if improved diagnostic methods permit the identification of patients with far less severe manifestations than the originally described cases. For example, quantitative criteria released by Medicare in 1998 for determining whether or not patients qualify for hospice care state that "ALS tends to progress in a linear fashion over time" and that "the overall rate of decline in each patient is fairly constant and predictable." Yet, one ALS patient described by Dr Lawrence Huntoon has defied all odds and remained fairly stable for 10 years. Physicians must resist the tendency to reduce illness to a set of numbers with courses plotted on a graph and with rationing decisions made on that basis.

Two examples to remember of the triumph of the human spirit over devastating neurologic disease are these: Franz Rosenzweig, diagnosed with ALS in 1922, began work in 1925 on one of the most significant Bible translations of modern times, in collaboration with Martin Buber. Work on Genesis through Isaiah was finalized before Rosenzweig's death in 1929, by which time he could move only his eyes. British cosmologist Stephen Hawking has survived the diagnosis of ALS for more than 32 years. He writes:

> I have had motor neurone disease for practically all my adult life. Yet it has not prevented me from having a very attractive family, and being successful in my work. This is thanks to the help I have received from Jane, my children, and a large number of other people and organizations. I have been lucky, that my condition has progressed more slowly than is often the case. But it shows that one need not lose hope (Hawking).

Appendix 26.1

Answer to Self-study Question on the Red Glass Test

The red glass test results were consistent with a weakness in the left medial rectus or with an internuclear ophthalmoplegia due to a lesion in the left MLF (Fig. 26-8). Though the patient was so bothered by the diplopia that she had to patch one eye while working at the computer, the neurologist found only bilateral horizontal nystagmus, more impressive in the right eye when looking to the right, on testing cardinal directions of gaze. A clinical diagnosis of MS was made, and

densities compatible with the plaques of demyelinating disease were seen on MRI.

(The patient noted that the distance between the two images was a semiquantitative measure that correlated with subjective severity of symptoms and could thus help measure progression of disease or response to treatment. Over the next couple of weeks, while on steroid therapy, she performed the red glass test daily. Gradually, the distance between the images diminished, until only one image was present.)

This was an unusual use of the red glass test, which is generally used to help identify a paretic muscle.

Appendix 26.2

Self-test on the Corneal Reflex

If neither eye blinks, the patient has a lesion of the ophthalmic branch of the right cranial nerve V (or conceivably a lesion of only the nasociliary branch).

If only the left eye blinks, the afferent (sensory) limb of the reflex arc is intact on the right. The efferent (motor) limb of the reflex is intact on the left but impaired on the right (because the orbicularis oculis is innervated by right cranial nerve VII). Thus, the diagnosis is a lesion of the right nerve VII.

Appendix 26.3

Why Parkinson Could Not Detect Cogwheeling

Parkinson practiced in the era of the gold-headed cane. At this time, doctors were so elevated above patients that they did not actually touch them except with the cane. Thus, there was no way that even an astute observer like Parkinson could detect cogwheeling.

Today, some clinicians will not touch a patient without donning disposable gloves. These should permit more information to be gleaned than a gold-headed cane would. Nevertheless, neither the loss of information nor the potential loss of the healing or comforting power of the human touch has been assessed.

Appendix 26.4

Delusions

Answers to questions on delusions on page 642:

1. The man was delusional. The culture's belief about the function of utility lines is rather unambiguous. Furthermore, physical inspection of the behavior of water pipes provides compelling contradictory evidence against their being used to suck money out of houses. The criterion of "firmly held" belief appears to be met because of the extreme state of privation and even death that resulted from adherence to this belief system.

   It is not possible to state whether his wife was delusional because we know nothing about her belief system. Even if they both had the same belief system, it would still be delusional and not acceptable on the grounds of religion because of the compelling contradictory evidence. Instead, we would refer to this as a *folie à deux* (the madness of two).
2. This probably represents a hallucination not a delusion. If he simply reported his visual experiences without the qualification of the phrase "he believed," we could make a definite diagnosis of hallucination. The patient's statement that he "believed" he had the reported sensory experiences is not sufficient to qualify as a delusional belief system.
3. Our culture does not teach this use for television programs. Assuming that standing in front of a public store window for hours qualifies the belief as "firmly held," this is a delusion.
4. The behavior may be fanaticism, and it may be dangerous, but it probably does not constitute a delusion based on the material presented. The judgments "unfair" and "inefficient" are value judgments that do not admit an external comparison. Thus, although the belief does meet the criterion of "firmly held," it is not out of keeping with his culture. It could only be so if he lived in a culture that prohibited the judgments "unfair" and "inefficient" (in which case he could be considered delusional).

This exercise helps, in this author's view, to show the difference between error and the psychiatric concept of delusion. An entire culture can be in error, but adherents to the error would not be diagnosed as delusional. Rather, in such a culture, a person who recognizes the truth would be considered delusional. In postmodern culture, a person who believes in the existence of objective truth may be considered delusional. Should this view prevail, the ultimate consequences for science and technology, and our civilization as a whole, are like those for the couple described in question 1 on a grand scale.

Appendix 26.5

Assessment of Affect

Answers to questions on page 646:

1. This is not an elevated or manic affect, but rather an inappropriate one. There is no expressed optimism or feeling of well-being concordant in verbal production and observed affect. Rather, there is discordancy.
2. This is a detached or flat affect.

Appendix 26.6

Hysteria

Answer to question in legend to Fig. 26-35, Grand Rounds with Charcot:

It is hard to know for certain which answers are correct because none could be proved from the photograph alone. It is more important that the student attempt an answer from his observation and reasoning. Such answers might include the following considerations:

1. The patient could have a conversion reaction.
2. A somatization disorder is an alternate or additional possibility (conversion and somatization disorder can coexist).
3. The patient could have a histrionic personality or simply be a suggestible person.

4. Although there is no group process demonstrable in the photograph, if one *believed* that the painting at the rear of the hall was being used to inform a contagious "group" process (by serial presentation), this too could be an acceptable answer. (There is some historic precedent for this belief; see Showalter [1997].)
5. Diagnoses should not be pejorative.
6. No evidence can be adduced from the figure for the doctrinaire psychoanalytic response, partly begun with Charcot's offhand comment to Freud, "Toujours meme chose. *Toujours la genitale*." (Always the same thing. Always the genitals.) (Note that hysteria is derived from the Greek hystera [uterus].)

Appendix 26.7

The Brief MAST (Pokorny et al., 1972)

1. Do you feel you are a normal drinker? (No = 2)
2. Do friends or relatives think you are a normal drinker? (No = 2)
3. Have you ever attended a meeting of Alcoholics Anonymous? (Yes = 5)
4. Have you ever lost friends or girlfriends/boyfriends because of drinking? (Yes = 2)
5. Have you ever gotten into trouble at work because of drinking? (Yes = 2)
6. Have you ever neglected your obligations, your family, or your work for two or more days in a row because you were drinking? (Yes = 2)
7. Have you ever had delirium tremens (DTs), experienced severe shaking, heard voices, or seen things that were not there after heavy drinking? (Yes = 2)
8. Have you ever gone to anyone for help about your drinking? (Yes = 5)
9. Have you ever been in a hospital because of drinking? (Yes = 5)
10. Have you ever been arrested for drunk driving or driving after drinking? (Yes = 2)

Scoring: 0–5, nonalcoholic; 26 or more, alcoholic. Intermediary scores are predominantly alcoholic.

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CHAPTER

27

Clinical Reasoning

If the fresh facts which come to our knowledge all fit themselves into the scheme, then our hypothesis may gradually become a solution.

—Sherlock Holmes, *The Adventures of Wisteria Lodge*

Points to Remember:

- A diagnosis is a decision about which disease model best fits the patient's condition. The decision, and the disease model itself, are tentative.
- One does not make a meal by tossing together every ingredient found in the pantry. Nor does one make a diagnosis by entering every item in a computerized checklist into an algorithm.
- Time spent solely for the purpose of "completing" a prescribed checklist to justify a billing code is *not* spent focused on patients and their illnesses.
- Experts develop sophisticated pattern-recognition skills, incorporating what is present and *not* present. This process is not reducible to a digitized formula. This chapter helps the student learn some of the components that will gradually be integrated into expertise.

Principles of Clinical Reasoning

Falsifiable Hypotheses

A falsifiable hypothesis is not a fraudulent or inappropriate hypothesis but rather one that is susceptible to being disproved (see Chapter 1). An example of a falsifiable hypothesis is: "The patient has consolidation in the left lower lobe."This is falsifiable because it is possible to demonstrate that there is no consolidation in the left lower lobe.

In contrast, Galen's hypothesis about his cure for the plague was not falsifiable: "This cure is efficacious in all cases in which it has been tried; except in those that were so sick that they were going to die anyway." One cannot prove that the survivors would have died if they had not received his cure (or that those who did die would not have lived without it).

A differential diagnosis (*vide infra*), as discussed in Chapter 3, should be a list of falsifiable hypotheses.

Negative Propositions

Negative propositions are frequent in medicine. Here are some clinical examples:

1. It is not possible to percuss the heart borders.
2. Persons who have one kidney removed never get compensatory hypertrophy of the remaining kidney.

Although negative propositions such as these are difficult to prove, they can be easily disproved (as by counterexample). In other words, they are falsifiable.

As a general rule, negative propositions, if universal, cannot be proved. For instance, if I say, "There are no unicorns," this implies that neither you nor I have yet seen a unicorn; furthermore, neither of us will find a unicorn in the future; and finally, there are no unicorns hiding in the basement (or perhaps on Mars) that we have overlooked. Such a universal proposition cannot be proved. However, a sufficiently restricted negative proposition can be proved, for example, "There are no visible unicorns in this room right now." Furthermore, the latter can be disproved (if you open your eyes and see one), so it is falsifiable.

Every positive proposition in a differential diagnosis list implies negative propositions regarding the other entries on the list, assuming that Occam's razor (see Chapter 26) holds. That fact, plus the general difficulty of proving negative propositions, may be the ultimate basis for the rule that "one should never say never in medicine."

Null Hypothesis

A restricted kind of negative proposition that is commonly used in science is called the *null hypothesis*. This is the hypothesis that states there are no differences between two groups.

Let us say that we have randomly allocated some patients suffering from a given disease into two groups. One group (the experimental group) is given a new medicine and the other (the control group) is treated identically except that it does not receive the new medicine. Differences in outcome between the two groups can legitimately be attributed to the new medicine; we avoid the *post hoc ergo propter hoc* fallacy (*vide infra*) by including a prospective control group.

Although we are seeking positive information by doing the experiment—about whether the new medicine does (or does not) work—we proceed by attempting to *disprove* the null hypothesis (i.e., by trying to refute the proposition that the two groups are as alike as two random samples drawn from the same population or universe). Customarily, we usually consider the null hypothesis to be disproved if the probability of the differences arising randomly is shown to be less than 5% ($p < 0.05$). Remember, however, that only a fraction of studies are published. The published one may have been the only one of 20 to show a "statistically significant" result.

In clinical medicine, we examine one patient at a time. In this setting, the null hypothesis is that he falls within the normal distribution of the rest of the population of healthy people (or of people who do not have the disease that is under consideration).

The student who is philosophically inclined will ask: Does this mean that medical research, and worse, clinical medicine, is basically probabilistic? The answer is yes. The conclusions are arrived

at in medical research by probabilistically refuting the restricted negative proposition known as the null hypothesis. (The restrictions are generally hidden in the case record or in the "Materials and Methods" section of a journal article.)

Indeed, all "proofs" related to real phenomena (that is, phenomena outside the abstract worlds of mathematics and symbolic logic) involve just this type of probabilistic thinking. This tends to be frustrating to the medical student, who is not trying to do something negative but rather to arrive at a positive diagnosis. In a fundamental sense, all positive diagnostic statements are umbilically related to the act of rejecting other possibilities (such as "normality"). In conditions like "essential hypertension," which are generally recognized to be "diagnoses of exclusion," the process is simply more obvious.

In summary, science cannot prove anything. The scientist is engaged in the activity of trying to *disprove* things.

To illustrate this point, there is an apocryphal story about Galileo. While he and a friend watched ice float down the river one winter, they fell into a dispute as to whether the ice floated because of surface tension and the flat shape of the ice floe or because the specific gravity of the ice was less than that of the water. The sun was shining, and they reasoned that *if* the sun melted the ice floe from the sides and changed its shape and *if* it then sank while they were watching it, those events would support the surface tension theory—but the ice floated around a bend in the river and disappeared.

They then proposed to go to the laboratory and carve a small piece of ice in the shape of the ice floe they were observing. This model could be placed in a vessel containing hot water. Again, *if* it melted from the side and *if* it then sank, those events in tandem would support the surface tension theory.

As they were proceeding to place the ice model into the water, Galileo suddenly had an idea and changed the experiment. "Instead," he exclaimed, "let's place the ice at the bottom of the water and see what happens."

Some historians of science consider this a pivotal point in the history of ideas. The advantage of Galileo's modification of the experiment was that whether the ice floated to the top or stayed on the bottom, the result would admit of one and only one of the two available hypotheses, having effectively refuted the other. This is the same type of reasoning that an effective clinician employs in his handling of signs, symptoms, and laboratory tests. He seeks tests whose results exclude one of the possibilities.

To return to the ice floe experiment, if the piece of ice failed to float to the top, then it could not be of less specific gravity than the water, and the surface tension theory must be correct. If it did float, it refuted the idea of surface tension as the explanation because surface tension did not operate at the bottom of the container, and so the specific gravity theory would stand. Of course, if there were a third explanation that neither Galileo nor his friend had considered, they could well draw an incorrect inference from the result of the experiment. Similarly, diagnosis by exclusion is treacherous if the differential diagnosis is incomplete.

Levels of Probability

To avoid error, it is important to keep the probabilistic nature of medicine constantly in mind whenever you listen to case presentations and read about clinical medicine. The probabilistic nature of your conclusions should be made as explicit as possible.

When negative propositions are presented, there are several possible levels of certainty. If someone makes a statement such as example 1 or 2 under the "Negative Propositions" section above, it might mean a number of different things.

First, the speaker may simply be stating a belief. Second, he may be recounting a remembered experience. Without documentation, this level is approximately as reliable as a statement of belief. (I have done a number of clinical projects in which I collected data prospectively by writing the clinical experience on a card and filing it out of sight. On a regular basis, I have found, on reviewing the written records, one or more situations I would otherwise have sworn I had never seen. Most clinical scientists have had similar experiences.) Third, the speaker or author may have documented personal experience. In this case, the proposition might be proved, if sufficiently restricted. (Proposition 1 is a good example. If the speaker cannot determine the heart borders by percussion, then the limited negative proposition might be true … for him. A problem is born, however, when he assumes that all others are equally lacking in this skill, that is, when he extrapolates from a limited negative proposition to a universal one.) Fourth, the speaker may intend to make a much stronger, more general statement: "It never was and we don't expect it to." The expectation may be based on a scientific body of work that predicts (but does not prove) that something will not happen in the future. Expectation, however reasonable, is still not a proof.

The scientific physician will strive to achieve the highest level of certainty that is possible and not to overstate the level of certainty that exists.

An Advanced Epistomologic Note

The odd relationship between positive and negative propositions was illustrated by *Wittgenstein's statement*: "It appears to me that negation in arithmetic is interesting only in conjunction with a certain generality.… I don't write $\sim(5 \times 5 = 30)$, I write $5 \times 5 \neq 30$, since I'm not negating anything but want to establish a relation between 5×5 and 30 (and hence something positive)" (Wittgenstein, 1975). A different example would be better for those not familiar with symbolic logic: We do not say "5×5 is roughly 26," we say, "5×5 is definitely not 30." Although the former might appear "closer," the latter, as a technique, would eventually allow us to exclude all the incorrect answers and so arrive at the correct one. The former statement is no more correct than the equivalent, but different, "5×5 is roughly 24," whereas the latter statement is invariably true.

Aphorisms

A Bestiary of Clinical Reasoning

A well-known aphorism says, "When you hear hoofbeats, they're probably coming from a horse, not a zebra" (Fig. 27-1).

Sometimes, the hoofbeats are not coming from either a zebra or a horse (Fig. 27-2), thus the need for differential diagnosis, arranged in order of probability. For hoofbeats, we would list: (a) horse, (b) bull, (c) zebra, and other unlikely possibilities. (One always likes to put a zebra at the *end* of the differential: "If you don't think about it, you'll never diagnose it.")

Then there is always the confounding possibility that it is a horse, but you *do not* hear any hoofbeats (Fig. 27-3).

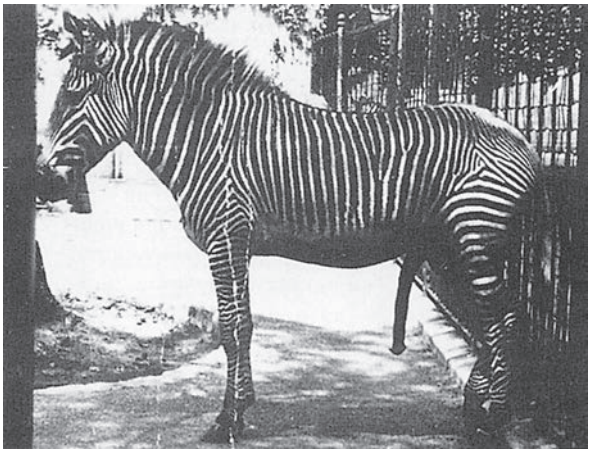

FIGURE 27-1 That famous zebra that is generally not responsible for the hoofbeats.

Sutton's Law

Ordering the differential diagnosis according to decreasing probability is a strategy in accordance with Sutton's law, which mandates "go where the money is."

Historic Note

The apocrypha states that Dr George Dock was a visiting professor at Yale, long ago when visiting professors were presented interesting patients to be discussed *viva voce* with no specific forewarning or preparation. Dock was presented a patient whom he thought was an easy puzzle, that is, the obvious test to perform was a liver biopsy, which would completely resolve the problem. Instead, he was given the results of every other available laboratory test, none of which was capable of resolving the issue. "Why don't you follow Sutton's law?" he finally asked.

No one had ever heard of Sutton's law, so Dock told a story about the bank robber Willie "the Actor" Sutton. Sutton was famous for robbing banks, getting caught, and then escaping from prison by the use of subterfuge and costume (hence the nickname "the Actor"). Each time he escaped, he resumed robbing banks and was eventually returned to prison. Dock said that a newspaper reporter, wondering why the recidivist did not desist from the activity that regularly landed him in prison, asked him, "Why do you keep robbing banks, Willie?"

FIGURE 27-2 A nonzebra, nonhorse, which can produce hoofbeats.

FIGURE 27-3 A horse that did not produce hoofbeats.

Sutton allegedly replied, "Because that's where the money is."

Dock explained that in the case under discussion, the money was in the liver, and hence Sutton's law dictated that one should biopsy the liver.

Years later, Sutton was asked if he had actually made that statement, and he laughingly responded in the negative. However, he allowed that it was a good answer and that he would have said it if he had thought of it—but by that time, his name was already firmly ensconced in clinical lore.

Today, Sutton's law in medicine is all too often invoked in a different context: "money" is taken quite literally, and the money is no longer to be found in making the correct diagnosis or in any other activity related to patient care. On the contrary, the money is lost there as clinical expenditures constitute, by definition, the "medical loss ratio" (Orient and Wright, 1997).

Individual Variability or "The Law of Sigma"

Every probability distribution has a variance (σ); the standard deviation is an estimate of variance around a group mean. If an individual is somewhat different from the group, consider first the possibility that he is simply located near one of the tails of the distribution rather than a member of a different population altogether. This is an application of the null hypothesis: the individual is not significantly different from normal.

Occam's Razor

As explained in Chapter 26, the physician must try to explain the patient's problem as economically as possible (with the minimum number of separate diagnoses). For example, if a patient with an organic brain syndrome enters the hospital with a problem that could be explained either by (a) a new problem or (b) too much or too little of a medication prescribed for an old problem, bet on the latter.

Case Report

A patient had been discharged from the hospital with a prescription for phenytoin. Because most of his old records were lost, and

the patient had Wernicke–Korsakoff syndrome, it was not certain whether he had taken his phenytoin.

The patient was readmitted with orthostatic hypotension, nystagmus, truncal ataxia, and macrocytic anemia. The resident wisely stopped the phenytoin while waiting for the drug level to return from the laboratory.

The patient had lost his truncal ataxia by the time he was examined by the attending, who wrongly attributed its absence to an incorrect prior examination by the house officer. Worse, the attending violated the rule above and diagnosed several new entities instead of phenytoin intoxication.

The phenytoin level at admission came back markedly elevated.

Comment. Although this was not an easy case, following the rule would have enabled the attending to interpret better the loss of truncal ataxia. By the following day, the patient had also lost his nystagmus.

Other Aphorisms

For the Barking Dog and for Susann's law, see Chapter 26.

Inference

You will recognize inferential reasoning as illustrated in this anecdote:

Medical Student: "I saw Smith get on the bus this morning. He had been drinking and gambling."
Scientist: "Did you see him drinking?"
Medical Student: "No."
Scientist: "Did you see him gambling?"
Medical Student: "No."
Scientist: "Then how can you scientifically make the statement that he had been drinking and gambling?"
Medical Student: "When he got on the bus, he gave the driver a blue chip and told him to keep the change."

Still, inferential reasoning is full of potential for error (*vide infra*).

Frequently Violated Rules for the Logical Handling of Clinical Data

The logical handling of clinical data has been discussed in extended form (Bernard, 1957; Feinstein, 1967), but a few principles are listed here, in addition to those discussed above. I take them to be self-evident, and they were generally accepted by house staff, faculty, and students when presented in the form of an opinion questionnaire (Sapira, 1980). Nevertheless, they are frequently violated in practice.

Rule 1. If some of the findings supporting a new diagnosis can be reasonably rejected as either artifactual or related to a preexistent or coexistent diagnosis, such rejection of these findings does not, *per se*, refute either the new diagnosis or the verity of the other findings.

Rule 2. The fact that a finding is elicited by only a minority of observers does not mean that the finding can reasonably be rejected as artifactual.

Comment. If a finding is elicited, it is a finding, assuming that clinicians are not hallucinatory or tending toward intentional obfuscation. The finding could have been transient, or perhaps only a minority of the observers might have the skills to elicit it, or perhaps it was misinterpreted or overinterpreted by an unskilled examiner.

Dr Claude Bernard was frequently asked how one could determine which of two identical experiments yielding contrary results should be considered the correct one. Dr Bernard answered that both should be considered correct because two identical experiments could not yield different results. He then pointed out that to yield opposite results, there must have been unrecognized and differing conditions between the two experiments and these would ultimately be shown to be the cause of the differing results. I believe Bernard's rule is the antecedent of this second principle.

Rule 3. If there are findings whose validity is not contested, supporting a diagnosis with which a consultant does not agree, the consultant is obligated to offer an alternative diagnosis that will also explain the findings.

Rule 4. Positive findings are more important than negative findings, except for those negative findings that are known as "excluders." (For example, the absence of an increase in the serum bromide concentration would be an "excluder" for the diagnosis of bromism.)

Comment. The antecedent of this principle was apparently formulated by Dr Jack Myers and popularized by Dr Eugene Stead:

> Jack Myers frequently said that much clinical learning could be summarized by the following statement: Any positive observation has greater weight than any negative observation. If a marble is found in a room, that is a positive observation and, in general, means that the room did contain a marble. If the doctor finds no marble on searching the room, it may mean that there is no marble there, but many times it will mean that the doctor is not good at finding marbles (Stead, 1978).

Rule 5. If a patient has *n* findings, the patient's diagnosis (or diagnoses) should explain all *n* findings.

Comment. This principle is most frequently violated by sophomore medical students. Because of their praiseworthy intent to "get *the* diagnosis" (which they correctly assume to be a precondition for the patient's selection for examination by medical students), students emphasize those positive findings that support their first diagnosis but fail to consider other findings that would suggest an alternative diagnosis.

Logical Fallacies

Post Hoc Ergo Propter Hoc

The Latin expression in this section heading means: "After this, therefore, because of this." It refers to one of the most common errors of logic committed in the daily clinical practice of medicine: assuming that if A follows B, A was caused by B. The fallacy's very ubiquity breeds a malignant tolerance: Some persons are unable to accept the fact that an error is being committed even when it is pointed out. Enlightened clinicians may not like to believe themselves capable of making such an unreasonable assumption, but in fact, the inference that sequence is evidence of causality seems so eminently reasonable that the fallacy is easily perpetrated in our very best hospitals, books, journals, and offices. (In fact, sometimes the sequence is reasonable; so far, no one has suggested that Saint Sebastian [see Fig. 5-2] was secreting those arrows!)

Post hoc ergo propter hoc is a special case of an associative fallacy. For example, although it is true that there is a strong statistical association between height and weight, it would be erroneous to conclude that one could become taller simply by overeating. Otherwise the complaint of the fat man, "I'm not overweight: I'm just too short" would be true.

Go to the chart rack and pick up any chart. You might see in bold red letters on the outside: "Allergic to codeine." What is the scientific basis for such a statement?

To be sure that the patient had an allergic reaction, it should have been replicated on challenge, preferably blind, and must be the sort of reaction recognized as allergic, not simply the pharmacologic (e.g., a histamine-releasing) effect of codeine. However, upon interviewing the patient, one finds that the patient noticed some event that followed the administration of what was believed to have been codeine and assumed a causal relationship. Sometimes the effect attributed to the drug and the time interval described are so unlikely that the chance of causal association is slight. At other times, however, the effect (e.g., nausea) and the time interval are quite good for assuming a causal (if not necessarily allergic) association.

Of course, nothing is wrong with making an assumption as long as one recognizes what one is doing. It is often safer to accept the assumption than to take the risk of a provocative test. However, with *post hoc ergo propter hoc* such an assumption is often accepted as if it had been proved.

The importance of establishing the likelihood of causality becomes apparent when the patient has a serious infection that is preferably treated by an antibiotic to which the patient is thought (by *post hoc ergo propter hoc* reasoning) to be allergic. In the broader sense, many expensive and onerous restrictions based on the "precautionary principle"—which itself is largely based on the *post hoc ergo propter hoc* assumption—eventually have the effect of increasing risk by decreasing flexibility and mandating actions with their own unrecognized adverse effects (Orient, 1996b).

Open a chart, and you may find a statement like this in the progress notes: "The fever has responded well to antibiotics. Cultures still negative."

First of all, antibiotics are not hypothermic. *Infections* may respond to antibiotics but fevers do not. At this point, we are not sure that the antibiotics chosen are appropriate for the organism or even that the patient has an infection. In fact, the patient might have a collagen-vascular disease.

It would be much better to enter the note: "Patient afebrile. Cultures still negative." This contains the same information in fewer words without the error in logic.

Although the argument may seem trivial, consider the patient who has unbeknownst to his doctors developed a febrile drug reaction due to one of the "covering" antibiotics. The logical fallacy may lead to treatment inadvertently based on the hair of the dog, that is, more antibiotics are added to "cover" the fallaciously assumed microbial cause of the fever. (Perhaps a dog chasing its tail might be a more suitable image.)

Thus, the *post hoc ergo propter hoc* fallacy has great potential for harm, especially in those situations in which it may seem the most reasonable.

Discounting of One Etiology by Eliminating Only One of Multiple Subcomponents

Consider a situation in which syndrome Z can be caused by etiology 1 or etiology 2. Etiology 2 is usually the result of condition A, although it is sometimes the result of condition B. (You may wish to diagram this.) Suppose that a patient with syndrome Z has been proved not to have A. It would then be erroneous to conclude that his syndrome must have been caused by etiology 1.

A specific case might be hypokalemia with hyperkaliuria, which can be caused by renal tubular acidosis (RTA) type 1 or type 2. It can also be caused by mineralocorticoid excess. For the sake of discussion, assume that all other "nonrenal" causes of hypokalemia with hyperkaliuria (diuretics, other drugs, etc.) have been eliminated. Because the patient has a urinary pH of 5.2, it is accepted that he cannot have RTA type 1. However, it would be a fallacy to conclude that he must have mineralocorticoid excess. Why? Write your analysis down before consulting Appendix 27.1.

Differential Diagnosis

Use of Differential Diagnosis as a Guide to Reading

A Personal Perspective

When I was a depressed and anxious freshman in medical school, I approached one of the sophomores, Howie Reidbord, whom I had known in college. I asked what distinguished the students at the top of the class from the students at the bottom of the class, a question of more than casual interest as the bottom 20% did not graduate. "Reading," said the future Dr Reidbord. "The ones at the top read more than the ones at the bottom."

It is impossible to communicate what that time and place were like to those who were not there—but let me give one example.

When I was a medical resident, I was reading in the hospital library one evening. As I finished one article and lifted my head to the next article in the stack, I saw an orderly sitting across from me reading a cardiology textbook. Each time I got another article from the stack, I noticed that he was still there, reading intently. Finally, I asked him what he was doing. "Reading about my patients," he answered, as if to say, why else would somebody be in the library reading medical texts.

I thought I might have misidentified his white uniform, but he truly was an orderly, who was serving a 2-year sentence to public service because of moral objections to the then nascent Vietnam War. He too stayed after his duty hours to read about his patients. It would be misleading to say that everybody always read about all of his patients, but the story illustrates the intellectual environment of the times.[1]

[1] Readers who take exception to the author's comments about the deterioration in American medical education in the past 20 years (under the aegis of experts who say they are "in favor of education") are invited to consider how many of the more than 100 medical schools in the United States require demonstrated proof of competence in differential diagnosis for promotion (none that I have been able to determine). Yet, this keystone of the diagnostic process is pertinent even for those who rely on herbal teas for therapy, being utilized in parts of *A Barefoot Doctor's Manual!*

The difference in today's environment is eloquently expressed in an article about a conveniently located "evidence cart," which concluded that "it is not known whether clinical services busier than ours could afford the time required to find and discuss evidence in this fashion, although most searching … could be completed … in less than 30 seconds" (Sackett et al., 1998).

How Much Reading Is Necessary?

Once you have compiled a differential diagnosis, it becomes obvious that you must learn something about each entity on the list to find out how close the match is between the abstraction of the disease and the reality of the findings in each patient. Accordingly, if you have a differential of 10 diseases for one patient, then you must read about 10 diseases. If there are two differential diagnoses being developed for a patient and each of them contains 10 different entities, then you must read about 20 diseases, unless some diseases appear on both lists. In the last case, by Occam's razor, the patient should have one of the diseases that is on both lists (*vide infra*).

This investment of time will pay handsome dividends not only in learning specific facts about a disease, but in the inestimably valuable skill of learning how to teach yourself. The most effective self-teaching occurs if you read about the patient before you go to sleep that night.

How Should One Begin the Differential Diagnosis?

If a patient presents with only one symptom, such as headache, or only one sign, such as a systolic murmur, it is obvious that the differential diagnosis must concern that symptom or sign. However, patients often present with many signs and symptoms. The beginning student needs a strategy for deciding on the symptoms and signs on which to concentrate.

One good rule is to select the sign or symptom that has the fewest possible explanations. For example, if a patient complained only of headache, you would have to do the differential diagnosis of headache. However, if the patient also had fever, chest pain, nausea, vomiting, malaise, and leukocytosis, it would be unreasonable to start with the differential diagnosis of headache because that symptom is a feature of so many different diseases. Chest pain would be a better symptom on which to focus.

As a case in point, two sophomore students saw a patient whose chief complaint was pauciarticular arthralgia of several days' duration. The patient was an intravenous drug abuser, who on physical examination had a grade 5 out of 6 holosystolic murmur, radiating to the axilla. Starting with the arthralgias and reading the usual rheumatology textbooks, one would have great difficulty arriving at the diagnosis of infectious endocarditis, and in fact might be led to the incorrect diagnosis of lupus erythematosus. On the other hand, starting with the description of the murmur, one could quickly eliminate all possibilities except disease of the mitral valve. The differential diagnosis of acute mitral insufficiency in a febrile drug abuser quickly leads to consideration of infective endocarditis. Reading about this entity in any good textbook would soon yield the explanation for the arthralgias.

For the Attending. This method of teaching is highly structured. I refer to it as "iterative" (*vide infra*) because it requires making a list and proceeding in an orderly fashion. Good diagnosticians, of course, do not actually make diagnoses that way, but rather by "model building," which requires processing vast amounts of information, mostly out of consciousness. (Actually, the example given above uses model building to select the *combination* of findings from which to begin the differential diagnosis.) I cannot teach "model building" explicitly, but good students will acquire it. In the past, those who could not think this way did not get through medical school.

Today, there is a tendency to believe that the information processing can be done by a computer, making this clinical process obsolete. However, the first problem the computer confronts may be insurmountable: Where does it start?

Preparing a Differential Diagnosis from a Case Record

A Method

The following method is presented for the beginner who has the task of analyzing a case record prepared by someone else (as for the traditional clinical pathologic conference).

Assumptions

1. There is one major, "unknown," correct diagnosis.
2. The abstractor has included in the case record all the information required to arrive at the correct diagnosis.
3. The findings are described accurately; for example, the patient is not said to have a diastolic murmur when the murmur is actually systolic.
4. The person analyzing the case record has access to a medical library.

Sequence of the Analysis

The following steps are diagrammed in Figure 27-4:

1. Read the case history once.
2. Read it a second time, underlining all symptoms, signs, and abnormal laboratory results (collectively referred to as the "findings").
3. Pick a single leading finding. (At first try, you might choose one with which you are familiar from prior reading.)
4. Write down the differential diagnosis of this leading symptom or sign. Until you are adept at composing your own differential, you should copy one from an expert. In addition to a medical textbook, you might wish to use the MacBryde Signs and Symptoms (Blacklow, 1983) or a similar source.
5. List the findings that are "always" and "frequently" associated with the disease at the top of the differential diagnosis. You may need to read more about that particular disease.
6. Review the case history. Are there any findings "always" associated with the disease under consideration, which are specifically missing from the case record? If "yes," cross that disease from the list and repeat step 5 with the next disease in the differential. If "no," proceed to step 7.
7. Is there any outstanding finding in the case record that is not explained by the disease under consideration? If "yes," cross the disease off the list and go back to step 5 (but remember that in real life, patients can have more than one disease). If "no," proceed to step 8.
8. Examine the list of "frequent" findings prepared in step 5. Do they match poorly with the findings in the case record? If

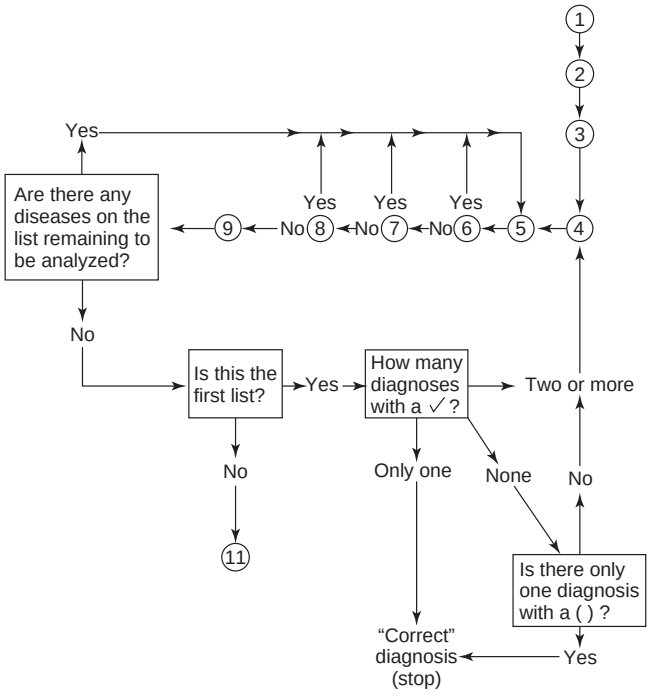

FIGURE 27-4 Steps in preparing a differential diagnosis (see text).

so, cross the disease off the list and repeat step 5 for the next disease in the differential. If not, proceed to step 9.

9. Are there a number of findings in the case record that are not explained by the diagnosis under consideration? If "yes," place parentheses around the diagnosis, and go back to step 5. If no, place a check next to the diagnosis and return to step 5.
10. When you have performed steps 5 through 9 for all the diseases on the list, you may have arrived at a diagnosis. If there is only one disease with a check, that is the most likely diagnosis. If there is more than one disease checked, or if no diseases are checked, but two or more are in (exclusionary) parentheses, you have identified the set that probably contains the correct diagnosis and will need to proceed to step 11.
11. Repeat the procedure, starting with the second leading finding, and see what diagnosis appears most likely on *both* lists. You may need to use still more findings until only one diagnosis emerges as the most likely.

An Example

The lists described in the method above are called *iterative*, from the Latin *iter* meaning "to plow again." To be more specific, let us give an example of the use of iteration.

Consider the situation of a patient whose hematocrit is rapidly dropping, and who has a negative stool guaiac, and no evidence of intravascular hemolysis. Such a case could be analyzed either by consulting a series of differential diagnostic lists or by having access to a single differential list called, perhaps, "occult bleeding with a negative stool guaiac and no hemolysis":

1. Bleeding into the lung
2. Bleeding into the pericardium
3. Bleeding into the peritoneum
4. Bleeding into muscles, including the retroperitoneum
   a. Bleeding into muscles
   b. Bleeding retroperitoneally without muscle hematoma.
   c. Bleeding both into muscles and the retroperitoneum
5. Bleeding into the central nervous system (presumably this would cause neurologic signs and symptoms)
6. Bleeding into the kidneys
7. Bleeding into the liver
8. Bleeding into the gastrointestinal tract (presumably outdated guaiac was used for the test)
9. Bleeding into joints

This differential diagnosis is not necessarily listed in order of decreasing probability for every patient (e.g., the presence or absence of neurologic signs would, as noted, move item 5 higher or lower).

Formulating Lists of Differential Diagnoses

A number of books that discuss leading signs and symptoms are still available. These vary from those with an extensive pathophysiologic emphasis to those that are nothing more than collections of lists. In an earlier era, students would compile and collect their own lists. Today, they may rely on a program for their palm pilot or on Internet searches. It remains to be seen whether overreliance on electronic tools early in one's medical education has the same effect on clinical acumen as that of the early use of calculators on mathematical ability.

Formulating a list for differential diagnosis obviously requires some familiarity with medicine, but even a student who has completed a course in sophomore pathology should be able to do so. A grid system may be composed, listing body organ (or physiologic system) on the horizontal axis and pathophysiologic process on the vertical axis. These processes traditionally include:

1. Inflammation
2. Neoplasia
3. Disturbance of flow
4. Metabolic factors
5. Congenital factors
6. Vascular factors and sometimes others, such as "iatrogenic" or mechanical

Sometimes one of these rows will be blank; for example, the thymus, being a solid organ, would not experience disturbance of flow. At other times, the entire system might collapse to only one column; for example, splenomegaly would only involve analyzing one organ, the spleen. Similarly, the category of diseases involving one organ or system might be subdivided into primary (e.g., diseases directly affecting the spleen) or secondary (e.g., secondary splenomegaly due to portal hypertension due to primary liver disease).

Sometimes, the pathophysiologic entry needs to be expanded. For example, inflammation could be split into primary inflammatory (e.g., sarcoidosis) and infectious, and the latter in turn could be subdivided into classes of infectious agents (protozoal, bacterial, viral, fungal, etc.). Each of these could be divided still further. "Bacterial," for instance, could be classed by staining property, morphology, and so forth.

Separating clusters of findings in the dimension of time (acute vs. chronic) and grouping them selectively in a meaningful manner is also useful, especially in the increasing number of chronic prediagnosed conditions. For instance: "The sudden appearance or worsening of dyspnea in a patient known to have chronic pulmonary insufficiency suggests the supervention of either pneumonia, pulmonary embolus, or left heart failure." Here, the prediagnosed condition is "*chronic* pulmonary insufficiency," and the "sudden appearance" or "worsening" of the dyspnea is the *acute* modifier.

Examples of some differential diagnoses are given in Chapter 20 (splenomegaly), Chapter 16 (auscultatory findings in the chest), and Chapter 25 (pitting edema).

Self-test

The following exercise tests whether a medical student can understand and apply these *concepts*. It is "information free" (i.e., not dependent on specific instructional experiences of the student):

Two astronauts are sent by spaceship to the distant planet Grlth, which is inhabited by a tribe of five-legged creatures known as Chmendricks. For 2 weeks, the astronauts live among the Chmendricks, exchanging earth food and Grlth food, with no apparent adverse effects to either group. The astronauts learn that they can remove their spacesuits because the planet's atmosphere is identical to that of the earth (i.e., astronauts and Chmendricks respire in a similar way). It is of interest that none of the astronauts or the Chmendricks that come in contact with them develop illness.

As the astronauts lift off for their return trip home, the King of the Chmendricks waves his right talon in a gesture of farewell. At this moment, one of the astronauts notices a discoloration of the third phalanx of the talon.

Give a 20-item differential diagnosis of this discoloration. The items do not have to be listed in order of probability. You have up to 1 week to conceptualize how you will perform the differential diagnosis. Once you start writing, you have 20 minutes.

Diagnostic Strategies

Implicit assumptions about highly complex systems can often be made more salient and tested by means of oversimplified models that reflect basic characteristics of the system in a comprehensive manner. Here is such a model of diagnostic medicine.

Premises

A very simple model of a finite universe of diseases, each disease designated by a letter, is shown in Table 27.1. The diseases manifest varying symptoms, which are numbered. The table shows that symptom 1 can occur in diseases A through F. Symptom 2 is similarly nonspecific, occurring in diseases B through G, whereas symptom 3 may be seen in diseases E through J. Thus, not a single one of the symptoms is pathognomonic.

Similarly, the signs of this universe of diseases may be indicated by numbers. Again, the signs are not specific for any given disease. Furthermore, there are some diseases that have symptoms but no physical signs (diseases A, H, I, and J), which are in this respect like the real syndromes of acute hypercalcemia, hyponatremia, or some other metabolic disorders. Note that the sensitivity and specificity of the signs and symptoms are imperfect and unknown. We assume only that the patient has to have had at least one symptom in order to initiate contact with the diagnostician.

For each disease, let us assume that there is a laboratory test that is positive only and always in the presence of the corresponding disease (i.e., sensitivity and specificity are 100%). Each of these tests is indicated by a letter, corresponding to the respective disease. Let us further assume that the laboratory test always becomes positive early in the course of the disease, simultaneously with or preceding the appearance of the very first symptom of the disease. Of course, these assumptions would rarely, if ever, be true in real life. Nevertheless, a situation like this is the implicit goal of reductionistic medicine, and one is willing to accept the premise that it is a

TABLE **27.1** *A hypothetical universe of diseases, with their signs, symptoms, and laboratory tests*

	Symptoms			Signs			Laboratory tests									
Disease	1	2	3	1	2	3	A	B	C	D	E	F	G	H	I	J
A	X						X									
B	X	X		X				X								
C	X	X		X	X				X							
D	X	X		X	X					X						
E	X	X	X		X						X					
F	X	X	X									X				
G		X	X										X			
H			X											X		
I			X												X	
J			X													X

From Sapira JD. Diagnostic strategies. *South Med J.* 1981;74:582–584, with permission.

theoretically feasible one. So, these tests will be the "gold standards" of diagnosis for the purpose of this discussion (in mimicry of everyday beliefs in the value of the laboratory). The number of laboratory tests required to reach a diagnosis will be the dependent variable in the calculations to follow.

When shown this model and asked to develop a diagnostic method, clinicians offer a variety of strategies, strikingly reminiscent of those used in daily practice.

"Shotgunning"

One could simply order every available laboratory test, the real-world technique known as "shotgunning." In this model, it is a more rational strategy than in the real world because here we are not concerned with the morbidity or the cost of the tests; also these idealized tests have perfect sensitivities. This would require an average of 10 tests for correct diagnosis.

In the context of medical research, the trend toward the shotgunning method is well advanced. It is sometimes asserted that vast quantities of clinical data need to be collected from a population "sample" of 100% and placed into networked computers in order to find out "what works." The misleading results from obtaining too much irrelevant (not to mention faulty) data—such as the number of tests "abnormal" by chance alone—can result in faulty diagnosis and endless fruitless investigations in the individual case. An outbreak of population-wide fishing expeditions could lead to errors of monumental proportion (Orient, 1993, 1996a, 1997).

Diagnosis by Exclusion

If one further assumes all the patients have one of the ten diseases, it would be necessary to perform only nine tests to be certain of diagnosing every case. One test can be omitted; it does not matter which one. If all nine are normal, the patient obviously has the disease corresponding to the tenth (omitted) test. "Diagnosis by exclusion" may not work if the differential diagnosis is incomplete, but if it is complete there is an advantage over "shotgunning" in that only nine laboratory tests are required for correct diagnosis.

An Example of "Diagnosis by Exclusion"

Given a two-pan balance, and 13 externally identical billiard balls, of which 12 weigh exactly the same, the 13th being lighter, how many trials on the balance would be required to identify that one lighter ball?

Amazingly, it can be done in no more than three trials. (Stop and figure it out before reading Appendix 27.2.)

Sequential Searching

Laboratory tests include more possibilities than blood chemistries and the like, which are performed on specimens removed from the patient's body. There are also testing modalities that require the presence of the patient, such as electrocardiograms, radiographs, echocardiograms, radionuclide scans, and so forth. Thus, it may not be possible to obtain all laboratory tests simultaneously.

Clinicians familiar with this reality tend to modify the "diagnosis by exclusion" strategy into that of "sequential searching," halting the process as soon as a positive result is obtained. Diagnosing disease A would require only one test, B would require two, C would require three, and so on down to I and J, each of which would require nine. If we let the diseases be equiprevalent, the average number of tests required to diagnose the patient by this strategy would be

$$(1 + 2 + 3 + 4 + 5 + 7 + 8 + 9)/10 = 5.4$$

This is a significant improvement over the previous two strategies.

A corollary to the "sequential searching" method is that there is no point in performing a test if it is not going to alter your diagnosis, prognosis, or treatment in some way.

A specific example is the case of a patient with an enlarged liver. The resident suspected the diagnosis of acute alcoholic hepatitis, although on questioning he acknowledged that it might actually be viral hepatitis, both diagnoses being reasonable given the patient's history and physical findings.

When asked what he could do to eliminate acute alcoholic hepatitis from the differential, he named a liver enzyme test. However, he could not say how the results of the test would refute the hypothesis (i.e., he could not name a level of the enzyme at which he would drop either diagnosis). Therefore, he was advised not to order the test.

Utilizing Data from History and Physical Examination

Up to this point, all the strategies have involved manipulation of the "perfect" data (i.e., the laboratory tests). Would a strategy that utilizes the "imperfect" data obtained from the clinical examination be useful?

To answer this question, we first need to express the given information in the form of a matrix, as shown in Table 27.2. Each cell contains the diseases that could cause the concurrence of the symptoms indicated in the row, and the signs (if any) indicated in the columns; that is, each cell represents the differential diagnosis of the combination of symptom(s) and sign(s). In all the examples, the diseases are assumed to have equal prevalence. (Only a few cells have been filled in; you may fill in the rest.)

For a patient presenting only with symptom 3 and none of the physical signs, the differential diagnosis would comprise diseases E, F, G, H, I, and J (assuming their other symptoms and signs had not

TABLE **27.2** *Part of Table 27.1 from a clinician's viewpoint*

	Signs					
Symptoms	**None**	**1**	**2**	**3**	**1&2**	**2&3**
1	A, B, C, D, E, F					E
2	B, C, D, E, F, G					E
3	E, F, G, H, I, J	—	E	E, F, G	—	E
1 and 2	B, C, D, E, F					E
1 and 3	E, F					E
2 and 3	E, F, G					E
1, 2, and 3	E, F					E

From Sapira JD. Diagnostic strategies. *South Med J.* 1981;74:582–584, with permission.

yet appeared). The average number of laboratory tests required to reach the diagnosis would be

$$(1 + 2 + 3 + 4 + 5 + 5)/6 = 3.3$$

For a patient with both symptoms 1 and 2 but no signs, the patient could have diseases B, C, D, E, or F (albeit in an early form). Here the average number of laboratory tests required to diagnose a patient with this clinical presentation would be

$$(1 + 2 + 3 + 4 + 4)/5 = 2.8$$

For symptoms 1 and 3 together but with no signs, there are only two possibilities: diseases E and F. For this cell, only one laboratory test is required.

For symptom 3 and sign 1, Table 27.2 shows a dash. There is no disease that presents in this manner.

For the concurrence of symptom 3 and sign 2, there is only one possibility, disease E. Accordingly, zero laboratory tests would be required to find the single disease causing this particular presentation.

If one similarly calculates the average number of laboratory tests for each cell, the matrix shown in Table 27.3 is obtained. If one then assumes that the various clinical presentations are equiprevalent, one could calculate, for the 34 cells representing possible clinical presentations, the average number of laboratory tests that would be required to diagnose a patient within this universe of possibilities. It comes out to an astonishingly low 1.13 laboratory tests. In other words, a strategy involving combinations of imperfectly sensitive and imperfectly specific findings obtained from the clinical examination is a more powerful strategy than any of those exclusively involving direct manipulation of "perfect" laboratory tests.

Anticipated Objections

People usually respond to this demonstration in one of two ways. The first is to say that the model only presents a quantification of what has long been obvious to all good clinicians. (I agree.) The second response is one of disbelief based on objections to the ("additional") assumptions made in calculating the results of the last diagnostic strategy:

Disbeliever. You have assumed that the diseases within a cell are equiprevalent. This is not very likely, and it ignores the value of "clinical experience" in estimating the actual prevalence.

Answer. True. However, clinical experience will not help the "perfect" data strategies, which do not use clinical information, and clinical experience can only help, not hinder, the last strategy. For example, let us say that for the cell comprising symptom 3 and sign 3, the clinician has learned that the prevalence of the disease is such that G is greater than F is greater than E. If he switches his testing sequence from E, F, G to G, F, E, he would decrease the average number of laboratory tests needed to achieve a diagnosis within that cell.

Disbeliever. But you have also assumed that all presentations of the disease are equiprevalent. Yet you could not know this without knowing the natural history of each disease. Furthermore, this assumption contradicts the previous one, that the diseases are equiprevalent, because disease A appears in only one cell, whereas disease E appears in many cells. If you corrected for true prevalence, would it not change the result and the conclusion?

Answer. It would change the numeric value of the result but not the conclusion. The mean values for each of the individual cells in Table 27.3 range from 0 to 3.3 tests per cell. Therefore, no matter how the individual cells were weighted for prevalence, the mean value for the universe will still be between 0 and 3.3. Thus, the highest possible value is still lower than 5.4, which was the best result of the strategies using only "perfect" laboratory data, and the conclusion would not change.

TABLE **27.3** *Diagnostic matrix derived from Table 27.2*

	Signs					
Symptoms	**0**	**1**	**2**	**3**	**1&2**	**2&3**
1	3.3	1.7	1.7	1.0	1.0	0
2	3.3	1.7	1.7	1.7	1.0	0
3	3.3	—	0	1.7	—	0
1 and 2	2.8	1.7	1.7	1.0	1.0	0
1 and 3	1.0	—	0	1.0	—	0
2 and 3	1.7	—	0	1.7	—	0
1, 2, and 3	1.0	—	0	1.0	—	0

From Sapira JD. Diagnostic strategies. *South Med J.* 1981;74:582–584, with permission.

Developing a More Sophisticated Model

One could refine this model by finding the actual values for sensitivity, specificity, and prevalence of disease, preferably performing the calculations by means of a high-speed computer with an elevated threshold for boredom.

Increasing the Level of Complexity as a Problem-Solving Device

Let us say that a physician has examined a patient and determined that the patient is disoriented to time. By considering the differential diagnosis of "disorientation to time" and performing the rest of the mental status examination, one can make a more specific diagnosis, perhaps "organic brain syndrome."

Next, one could review the past medical records and determine that the patient has been disoriented either acutely or for some time. If the patient has been disoriented acutely, one does the differential diagnosis of "acute organic brain syndrome"; and if the patient has been disoriented for some time, one does the differential diagnosis of "chronic organic brain syndrome."

Next, one could perform a neurologic examination and determine whether or not focal findings are present. Let us say they are not. The level of complexity now changes to "acute organic brain syndrome, no focal findings" or "chronic organic brain syndrome, no focal findings."

At this point, the differential diagnosis of "acute brain syndrome" would be given by the outline in Table 27.4.

TABLE **27.4** *Outline of causes for organic brain syndromes as well as other conditions of central neutropenia*

I. Inadequate metabolic supply
  A. Hypoxia (e.g., decreased arterial pO_2, CO, or cyanide poisoning, methemoglobinemia, or sulfhemoglobinemia)
  B. Decreased glucose (hypoglycemia)
  C. Decreased delivery of substrates to the brain (decreased cerebral perfusion due to vascular obstruction, decreased cardiac output as in shock, etc.)
II. Inadequate metabolic milieu
  A. Systemic alterations in metabolism reflected in the brain (hypothyroidism, nutritional deficiencies such as vitamin B_{12}, thiamine, niacin, etc.)
  B. Alterations of pH (acidosis or alkalosis, respiratory or metabolic)
  C. Alterations in ionic composition (e.g., as in uremia, especially acute; poisonings)
III. Inadequate physical milieu
  A. Mechanical disease of the central nervous system
    1. Trauma
    2. Tumors and other space-occupying lesions
  B. Inflammation (bacterial, fungal, etc.)
  C. Tissue destruction or degeneration
  D. Alterations in osmolality (hyperosmolar and hypoosmolar syndromes)
  E. Alterations in cerebrospinal fluid pressure
  F. Other

It is worth noting that the same table outlines the differential diagnosis of the chronic organic brain syndromes, as well as that of stupor, coma, and syncope (also see Table 26.15). Of course, the emphasis changes; for example, with syncope, the mechanisms subsumed under part I, C (such as bradycardias, tachyarrhythmias, and vagal syncopes) increase in importance, while the metabolic causes are less prevalent.

Let us assume for the sake of argument that your patient has the "chronic organic mental syndrome—no focal signs," and using the outline given in Table 27.4, you have gone to the library to look up all the possibilities. The final list for this differential diagnosis seems overwhelming. You become discouraged because you have been taught that only 10% to 20% of the chronic organic brain syndromes have reversible etiologies (but see Chapter 26 regarding reason for more optimism). What should you do?

First, you might go down the list and eliminate all the irreversible etiologies. You will then have advanced one more level of complexity (all this with the same patient and problem) to the differential diagnosis of "chronic organic brain syndrome—no focal neurologic findings—reversible causes."

As the differential diagnosis is nothing but a list of testable hypotheses, you could then match each item on the list with a *specific* laboratory test that would detect the disease in question, were it present. In this way, your differential diagnosis would indicate the *orders* to write for working up the patient.

The orders would look like the items in Table 26.17. (Note that the history and physical examination for both the acute and the chronic brain syndromes would already point you to a number of diagnoses.)

Let us suppose that the thyroid function studies come back with a low thyroxine level, a low T_3 resin uptake and (just to be unambiguous) a low free thyroxine index, a low triiodothyronine, a low free triiodothyronine, a low reverse triiodothyronine, and normal serum proteins. (You may also fantasize that the patient has a low basal oxygen consumption, a low thyroid ^{131}I uptake at 6 and 24 hours, and a low butanol-extractable iodine, although just a fraction of these available tests would be required.) Such a patient has unequivocal hypothyroidism. Let us further assume that all the other tests are negative and that following treatment, the organic brain syndrome resolved.

You are finished with the case analysis, right? Wrong. You should now do the differential diagnosis of hypothyroidism, which is primarily the distinction between primary and secondary hypothyroidism. Let us assume that the thyroid-stimulating hormone is low. Now you have diagnosed secondary hypothyroidism.

Are you finished? No. Now you must do the differential diagnosis of secondary hypothyroidism (pituitary versus hypothalamic). Let us assume that it turns out to be pituitary. Are you finished yet?

No. You might want to determine whether the cause is pituitary apoplexy, hypophysitis, sarcoid infiltration of the pituitary, or any of the other items on that particular differential diagnosis.

Eventually, you may come to a point at which further progress is impractical, and here you might stop. The point is, however, that you can constantly improve your diagnostic acumen by forcing yourself always to progress to the next level of complexity.

An additional example is the analysis of edema (see Chapter 25).

A Nonstrategy of Nondiagnosis

The word "diagnosis" comes from the Greek *gnosis* meaning to know or understand, and the Greek *dia* meaning through or thorough, as in diameter. Thus, when you make the diagnosis, it means that you know the thing thoroughly. "The diagnosis" is not an imperfect or inaccurate impression, although "my diagnosis" might be.

Sometimes residents say that they do not need a diagnosis because they can "manage" the patient. When I observe the results of their "management" of such undiagnosed patients, I am often reminded of how one of my patients once used that term. She was a prostitute who referred to herself as a dancer, and to her procurer as her manager.

Diagnosis by Observing the Natural History

The term "diagnosis by observing the natural history" needs to be distinguished from "not making a diagnosis." The former was often used in earlier centuries when most patients were finally diagnosed at autopsy, and few diseases had effective treatments. Back then, following the patient until the disease "revealed" itself seldom did any harm.

Today, the main application of this strategy is in the outpatient evaluation of patients with poorly discerned findings, not suggestive

of the need for immediate further diagnostic activities. For example, a patient with aches and pains alone might be followed with "undifferentiated rheumatic disorder" until such time as it became clear that he had rheumatoid arthritis, ankylosing spondylitis, palindromic rheumatism, or some other recognized entity, of which the first manifestations had been truly nondiagnostic. Similarly, for physicians who believe in the distinction between the Raynaud phenomenon (secondary to another disorder) as opposed to Raynaud disease (unassociated with another disorder), it is obvious that the patient must be followed up for several years to determine whether another disease, such as lupus erythematosus or progressive systemic sclerosis, will manifest or not.

To call a strategy "diagnosis by observing the natural history of the disease" (as opposed to "waiting for the diagnosis to fall out of the sky") one must be able, at the initiation of the process of observation, to list almost every single disease that the patient might eventually turn out to have, as well as the ways in which it will become clear that he has or does not have each of them.

A Personal Memoir

Between 1959 and 1970, when I was learning to think under the diligent examples and vigorous expectations of the Pittsburgh faculty, I was always perplexed by how quickly they made "the" diagnosis, usually correctly. The weekly performance at Clinicopathologic Conferences (CPC), the like of which I have not seen or read about before, during, or since, was so astounding, that I carried a set of Pittsburgh CPC protocols with me for more than a decade after I was a full professor myself, trying to recapitulate their thinking from the notes I had made of their diagnostic explications. Someday, I told myself, I too would become a Great Rounder, but I would slow things up for my students and explain how the thing is done, not only that it can be done.

The present chapter is an admittedly feeble attempt, which falls short of the goal, not only by reason of the author's limitations, but also because there is something inherently unteachable in all this. I have noticed that as one progresses and gains *experience*,[2] there is some sort of automatic self-regulating internal system that reprograms one's thinking and improves one's diagnostic ability, provided that one was initially well educated and continues to read and see patients.

The present chapter is at best an attempt at recapitulating those ideas and techniques that have seemed at least to facilitate discussion of these issues, and so possibly to shorten the student's own apprentice time.

A Caveat on Matching Findings with Disease

While matching the findings of our patient with those of a comparison group of patients with a particular diagnosis, keep in mind that there are unmatched items that might be of interest. As Dr Hilton Terrell of South Carolina points out, the fact that we do not match for astrologic sign, barometric pressure, left-dominance, etc., means that we do not think these factors are important. Even if our beliefs are correct 99.9999% of the time, the fact that there is a huge number of potential factors makes it probable that several unmatched variables are acting to keep our relationships from being perfect. Moreover, the definition of disease is also messy. Many diagnostic categories are like a Chinese menu: two items from list A, one from list B, and nothing from list C. The DSM is the worst example, as its four revisions attest. The very definitions are problematic: Is a one-horned Asian rhinoceros a unicorn? Is a horse with a bony malformation of its face a unicorn?

Central and Peripheral Vision: The Limits of Rationality

As Gary Klein (*vide infra*) has pointed out, retinitis pigmentosa with loss of peripheral vision is more disorienting than macular degeneration with loss of central vision. He uses this as a metaphor for the dangers of hyperrationality: while we must use rational analysis to make fine discriminations and calculations, we need peripheral vision—experiential sources of power—to detect where to apply the analysis. Hyperrationality runs into problems in choosing how to decompose a task into elements. And it quickly runs into "combinatorial explosions." With Table 27.1, how do you pick the symptoms, signs, and diseases, and where do you stop? In real life, we use experience ("intuition"?) to frame situations and arrive at manageable representations (Klein, 1998). There is no one "right" way to do this. Computational power is not infinite, and the problem still has to be set up. "Information technology" is not a panacea, and in some situations, it could be more of an obstacle than an aid.

Clinical Experience and the Perils of Protocols

A personal memoir from Dr Lawrence Huntoon of New York:

> I was called to the emergency department to see a woman who, according to the emergency physician, was having an ischemic stroke. She was obtunded and had slurred speech. The CT scan was completely normal, showing no sign of blood or of an ischemic infarct. The patient met all the checklist criteria for giving thrombolytic therapy. The physician and the nurse in the emergency department strongly criticized me for not doing so, and threatened to report me to the hospital administration. Instead, I performed a lumbar puncture, knowing that 10% of the time, a subarachnoid hemorrhage does not show up on the CT scan. The CSF was grossly bloody. The patient had surgery for her ruptured aneurysm and emerged neurologically intact. Had I given the thrombolytic therapy, as the emergency room staff had been goading me to do, she almost certainly would have died.
>
> In this case, things just did not add up. The patient could move all four extremities. Although slurred speech can result from a lacunar infarct in the internal capsule that does not cause paralysis, such patients should be alert. An ischemic stroke that causes obtundation is always large and almost always involves an obvious paralysis.
>
> When the clinical picture just is not right, clinicians should discard the cookbook clinical pathways, such as tissue plasminogen activator (t-PA) protocols, and engage their brains in thought. While underrated and undervalued, thought saves lives.

[2] The key word is *experience*. Remember the internist's rebuttal to the surgeon who had claimed, "*I* have never seen that": "Excuse me. Doctor you've seen it. You just haven't *recognized* it." Dr. Andy Lonigio of Missouri has a similar story whose punch line is, "No, Doctor, you have not had 20 years of experience. You've had 1 year of experience repeated 20 times." The point is the same.

Expert Thinking, Advanced Pattern Recognition, and Seeing What is Not There

Experts do not use the laborious process outlined above, or branched-chain algorithms, or Bayes Theorem, as they make critical decisions under intense time pressure. They look; they *know*; they act. They see things that are apparently invisible to others. They recognize the absence of critical features in order to see what is wrong with a certain picture—as Dr Huntoon did in the example above.

The fire lieutenant who suddenly ordered his men out of a house while fighting what appeared to be an ordinary fire—just before the floor collapsed—said he had a "sixth sense." But careful debriefing revealed that he had noticed that the fire was too hot, too quiet, and not responding as expected to dousing with water. It just didn't fit his internal pattern-matching program, explains Gary Klein in a book on how experts make decisions. Nurses in a neonatal intensive care unit attributed their ability to recognize sepsis in tiny premature infants to "intuition" and "experience"—but were actually responding to subtle cues. How long does it take to develop such expertise? Klein writes that in many fields it takes about 10 years (Klein, 1998).

Through painstaking study and analysis, you will lay the foundation for the advanced heuristics you will use as an expert clinician. But some things can be learned only through apprenticeship and experience. Miss no opportunity to learn from an expert mentor at the bedside; do not place your trust in the digital computer. Be aware of the "culture of conformity and orthodoxy that begins in medical school" as a defense against uncertainty (Groopman, 2007). Do not allow it to suppress your thirst for truth or your desire to serve each individual patient.

Appendix 27.1

Analysis for the Problem in Logical Fallacies Section

Let X = hypokalemia with hyperkaliuria. Etiology 1 = nonrenal causes; etiology 2 = RTA (2A = RTA type 1; 2B = RTA type 2). It would be a fallacy to conclude that the patient under discussion must have mineralocorticoid excess because he could alternately have RTA type 2.

Appendix 27.2

A Method for Solving the Problem in Diagnosis by Exclusion Section

First take any six balls and compare them with any other six balls. If the pans balance, the lighter ball is obviously the one excluded. If the pans do not balance, the lighter ball is one of the six in the pan that has risen. Take these six and weigh three against three for the second trial. Obviously, the lighter ball is in the pan that rises. For the third and final trial, take any two of the three balls remaining under suspicion and compare them. If one pan rises, it contains the lighter ball. If the pans balance, the lighter ball is the one that was excluded from this final trial.

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CHAPTER 28

Some Bedside Laboratory Tricks

As Ponocrates grew familiar with Gargantua's vicious manner of studying, he began to plan a different course of education for the lad; but at first he let him go on as before knowing that nature does not endure abrupt changes without great violence.

—Rabelais, "The Old Education and the New," *Gargantua*, Book 1

Points to Remember:

- Take advantage of every opportunity to learn from pathologists or laboratory technicians about the performance and limitations of tests. Look at your own patients' slides when possible.
- An old-fashioned stained blood smear reveals many details about the cells that are not obtainable from an electronic hemogram.
- Simple, inexpensive bedside tests can point to difficult diagnoses and help to elucidate the pathophysiology of many diseases.
- It does not take too many examinations to learn to recognize reliably that something is "abnormal," even if you do not know what it is or what it is called. Simple intellectual honesty has saved more lives than profound encyclopedic knowledge.

Although not traditionally considered part of the clinical examination, laboratory diagnosis is simply an extension of the physical examination, albeit one that is now usually performed by persons unseen and not by the physician. Formerly, much of the laboratory examination was performed by the personal physician with the same advantages accruing as with the interview and the physical examination. Because some of these procedures are so simple and instructive and also because they have disappeared from recent textbooks, a selection is provided for the entertainment and enlightenment of young Gargantuas. The selection is based on matters that came up in the course of teaching at the bedside.

Shortly after the first edition of this book appeared, the US Congress passed the so-called Clinical Laboratory Improvement Act (CLIA) in reaction to some tragic consequences of false-negative Pap smears that had been performed, ironically, in federally regulated clinical laboratories. The Act applies to all laboratory examinations performed nationwide, subjecting physicians, even in remote rural areas, to onerous requirements such as the need to demonstrate periodically their ability to tell the difference between orange and red in order to be permitted to perform fungal cultures in their offices. Even the simplest tests such as a urine dipstick (which patients may perform themselves) require the payment of a fee to obtain a federal permit, although the more onerous paperwork and proficiency testing requirements are "waivered." The effect was to shut down many office laboratories.

It is not the intention of this book to advocate that students violate any federal laws. However, to the best of this author's knowledge, laboratory activity is still permitted for the purpose of education or entertainment. Students should take every opportunity to learn these useful skills. Some day, they may have occasion to use them to their patients' advantage in a setting in which CLIA's legal impediments to lifesaving or life-enhancing activities do not apply.

Unfortunately, it may be impossible to find the equipment and supplies with which to practice or to have the more experienced persons serve as mentors; advances in bedside laboratory diagnosis are not to be expected.

Blood

Whole Blood

Erythrocyte Sedimentation Rate

The rate at which erythrocytes sediment in anticoagulated whole blood is an indirect measure of fibrinogen and globulin. Thus, it is a poor man's interleukin-1 assay. This rate is elevated in a wide variety of conditions of infection, inflammation, tissue necrosis, and neoplasia. Because of its nondiagnosticity for single diseases, it has lost favor; it is now possible to distinguish, for example, angina pectoris from infarction or rheumatoid arthritis from osteoarthritis on other grounds. Still, the test has utility for screening large numbers of patients and for following therapy in inflammatory conditions such as rheumatoid arthritis. I also use it on a yearly basis when following hypochondriacal patients.

A Method

1. Place blood, anticoagulated with ethylenediamine tetraacetic acid (EDTA) or oxalate, in a Wintrobe tube, which is placed in a rack or taped to the wall behind the patient's bed. Be sure the tube is perfectly vertical.
2. One hour later, note, in millimeters, how much settling has taken place. (Measure from the top of the plasma to the top of the red cell column.)
3. Correct the sedimentation rate according to the hematocrit (Fig. 28-1). If the hematocrit is not already known, it can be determined on the same sample in the Wintrobe tube.

Interpretation

False-positive elevations in the sedimentation rate occur in old age and pregnancy.[1] False negatives (normal sedimentation rates) occur in typhoid fever, brucellosis, and 2% of cavitary tuberculosis cases.

[1] For the *Westergren* sedimentation rate, an age-correction formula has been derived (Miller et al., 1983) from a population of patients aged 20 to 65 years. For men, the upper limit of normal is obtained by dividing the age in years by 2. For women, add 10 to the age and divide the sum by 2.

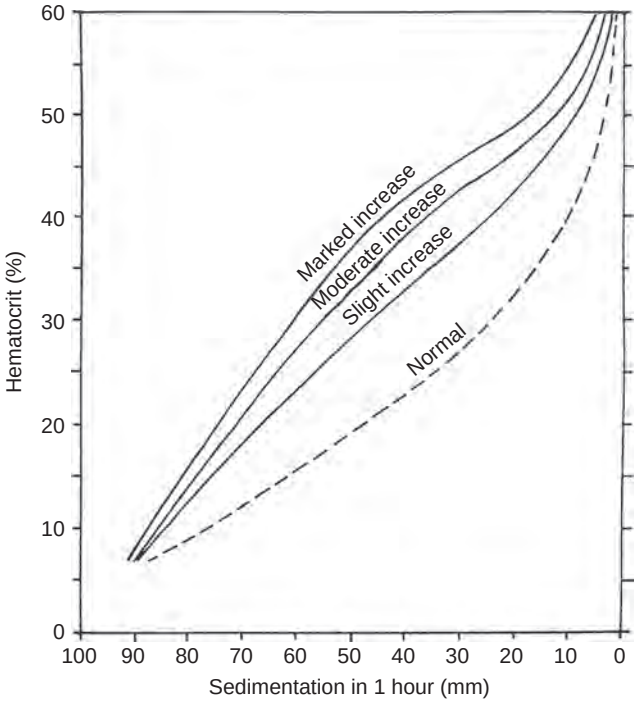

FIGURE 28-1 Reference chart for correcting the depth of sedimentation in 1 hour for the hematocrit, using the Wintrobe–Landsberg method. (Modified from Hynes M, Whitby EH. Correction of the sedimentation rate for anemia. *Lancet.* 1938;2:249–251, with permission.) The sedimentation rate is to be corrected from the observed hematocrit to a sedimentation that corresponds to a hematocrit of 45%. The normal range for the corrected sedimentation rate is 0 to 10 mm. Plot the point corresponding to the observed hematocrit and the observed sedimentation rate. This will fall in one of the zones indicating the approximate degree of increase in the rate. (Follow the nearest curve to the point where it intersects the line corresponding to a hematocrit of 45%. Read the corrected sedimentation rate. For example, if the observed sedimentation is 50 mm and the observed hematocrit is 25%, then the sedimentation in 1 hour corrected to a hematocrit of 45% is approximately 11 mm. If the observed sedimentation is 8 mm and the observed hematocrit is 56%, then the sedimentation in 1 hour corrected to a hematocrit of 45% is approximately 30 mm.) (From Wintrobe MM. Sedimentation rate vs. hematocrit. *Lancet.* 1938;4:30, with permission.)

Some viral infections do not increase the sedimentation rate, whereas some mild viral infections may do so (Ham et al., 1957; Wintrobe, 1967).

Lee–White Clotting Time

Current Usefulness

Although replaced in most laboratories by the various partial thromboplastin times, this test is still useful for diagnosing decreased amounts of procoagulants and for monitoring heparin therapy, if the partial thromboplastin time is not available. It can also be used in the "50/50" mixing test (*vide infra*), even if a partial thromboplastin time is available, simply as a matter of convenience.

A Method

1. Draw blood from a vein and place 2 mL in a Pyrex tube 8 × 15 × 100 mm. (Wider tubes yield longer clotting times, and smaller volumes yield shorter clotting times.) Note "zero time," defined as the moment that blood first appears in the syringe.
2. *Caveats*. The blood should be allowed to run down the side of the tube and specifically should not be "jet-sprayed" into the tube or handled in any way that will produce bubbles (Waldron and Duncan, 1954).
3. After 5 minutes have elapsed, begin tilting the tube to a 45-degree angle at 1-minute intervals.
4. The clotting time is the interval at which the tube can be inverted without displacing the clot. The normal time is 5 to 8 minutes (Todd and Sanford, 1948).

Variations. This test has been modified to use two, three, and even four tubes. One begins the stopwatch immediately after filling the tubes and starts tilting the first tube. When that one has clotted, proceed to the next one in turn. The intertilting interval may be shortened to 30 seconds but increased handling shortens the clotting time.

In some versions of the test, the tubes are placed in a 37°C water bath. In others, the tubes are prechilled by rinsing in iced saline. Under warmer conditions, the clotting time is slightly shorter.

Interpretation. When two tubes are used, the clotting time is the average unless the tubes vary by more than 5 minutes, in which case only the clotting time of the second tube is reported. The normal value is 4 to 12 minutes (Frommeyer and Epstein, 1957).

For three or four tubes, the clotting time is taken to be the time at which the last tube can be inverted. The normal is 5 to 15 minutes for three tubes and less than 17 minutes for four tubes (Wintrobe, 1967).

The most important issue in interpreting results is that the test should be performed under the same conditions each time.

History. The importance of drawing blood from the vein so as to avoid contact with tissue thromboplastin was already known to Howell in 1905. The test had been performed using a coagulometer by Pratt in 1903, and Morawitz and Bierch performed it using a glass tube in 1907. Addis had added the step of inverting the test tube for determining the end point at least by 1910. Other workers had performed essentially the same test, as noted by Lee and White, who wrote, "the method described is not completely new…" (Lee and White, 1913).

"50/50" Mixing Test for Circulating Anticoagulants

A patient with a prolonged clotting time may have a circulating anticoagulant instead of a simple deficiency of a clotting factor. To make this distinction, the clotting time (or other test of impaired coagulation, such as the automated partial thromboplastin time) is repeated, using a mixture of equal parts of the patient's blood and that of a normal person. The abnormal clotting test will become normal if the patient has insufficient clotting factors but not if a circulating anticoagulant is present. Preincubation at 37°C will increase the positive yield (Clyne and White, 1988).

The rationale for this test is as follows: If one views the clotting factors as operating in an enzymatic cascade, an improvement from near zero to 50% of normal will provide sufficient material to run the reaction. However, if there is an anticoagulant sufficient to impair normal levels of enzymes, the clotting test will still be abnormal if the anticoagulant is only diluted out by one half.

Blood Clot Tests

Observe a perfectly vertical tube of blood that has been taped to the wall next to the patient's bed.

1. If no clot ever forms, the fibrinogen content of the blood is thought to be very low, less than 60 mg per dL.
2. If the clot dissolves within 20 or 30 minutes, the patient has hypofibrinogenemia or accelerated fibrinolysis.
3. Clot retraction begins at about 1 hour and reaches a maximum in less than a day. With normal clot retraction, the clot becomes progressively smaller, leaving a space of completely clear serum behind it. Impaired clot retraction occurs more slowly than normal. Also, the red cells are not trapped effectively, so they leak out of the clot, fall through the serum, and coat the floor of the test tube.

   Clot retraction depends on normal platelet number and function. If the platelets are decreased in number, there will be a decrease in clot retraction. Impaired clot retraction in the presence of a normal platelet count makes the diagnosis of "thrombasthenia" (weak platelets), or what we would now refer to as the family of "numerically adequate but functionally inferior" platelet syndromes. In fact, this is the only bedside test that distinguishes "thrombasthenia" from vascular defects (such as those found in scurvy or amyloidosis).

   False Negatives. These are falsely normal-appearing clot retractions despite impaired platelet function. With hypofibrinogenemia, fibrinolysis, or severe anemia, the abnormally small clot may mimic a normal clot that has retracted.

   False Positives. Polycythemia may cause the clot to appear "too big" despite normal retraction. (For more on platelets, see "Rumpel–Leeds Test," Chapter 7, and the section on "Platelets" in this chapter.)
4. Leave the tube of blood up for more than a day to check for normal fibrinolysis.

Test for Heparin-Induced "White Clot" Syndrome

Occasionally, heparin induces immune-mediated platelet aggregation, causing thrombocytopenia and paradoxic thromboemboli. The emboli are ghostly white and consist of platelet aggregates and fibrin.

A Method

Mix platelet-rich plasma from a control subject with platelet-poor plasma from a patient. If the patient has white clot syndrome, his plasma will sensitize the platelets of the control subject. With the addition of 1 unit of heparin per cubic centimeter of plasma, plus adenosine diphosphate solution, a platelet aggregate will form. This may be obvious to inspection or can be quantitated with a platelet aggregometer (Stanton et al., 1988).

Formed Elements of the Blood

First, clinical microscopy was purged from the curriculum because there was no National Board Examination in it. Then, manual differential counts were automated, to the further detriment of patients, as certain kinds of findings were lost. This section is concerned with what was lost (and can be regained) rather than with cost effectiveness. It is intended to show neophytes and those who instruct them that there is both utility and pleasure in finding things for one's self in the laboratory, in exact analogy to interviewing and examining one's own patient.

How to Make a Blood Smear

1. Place a thick glass slide on a solid surface, frosted side up. Write the patient's name and the date in pencil on the frosted area.
2. Place a drop of blood very near one end of the slide. Hold the other end with the fingers of your nondominant hand.
3. With your dominant hand, pick up a second glass slide to be used as a spreading device. Hold it at a 45-degree angle to the first slide, and place its edge near the drop of blood, between the drop and your nondominant hand. (The drop will now be in the 45-degree angle formed by the two slides; see Fig. 28-2.)
4. Bring the second slide back toward the drop of blood. When it touches the drop, surface tension will cause the drop suddenly to spread out all along the length of the touching slides (see Fig. 28-2).
5. Quickly move the second slide toward your nondominant hand. This will pull the blood behind it and spread the blood over the glass without pressing on the blood corpuscles (Fig. 28-2).
6. A perfect blood film will have a feathery edge. Usually, it takes two or three practice runs under supervision to produce such an edge, but once you learn the skill you will never lose it.
7. Allow the slide to dry (fix). Stain it according to the local ground rules, or the following procedure.

Staining a Peripheral Blood Smear

1. Place the smear on a support such as a cork nailed to a board or two rods hung over a sink.
2. When it is completely air dried (fixed), pour Wright stain on it so as to cover the entire slide. Wait 3 to 5 minutes.
3. Add the prepared buffer. Use enough to make the surface of the stain appear iridescent but not so much that the overlying fluid becomes transparent enough to see the smear beneath it. Mix in the traditional manner by gently blowing on the slide, not with a dowel rod or wooden applicator, lest the smear be disturbed.
4. After a few minutes, rinse with a wash bottle or under the tap and shake dry. Remaining topside bubbles may be blown off.
5. Blot with absorbent paper from the side. (Try not to touch the smear itself.)
6. The order of examination is as follows: (a) red cells, (b) white cells, and (c) platelets.

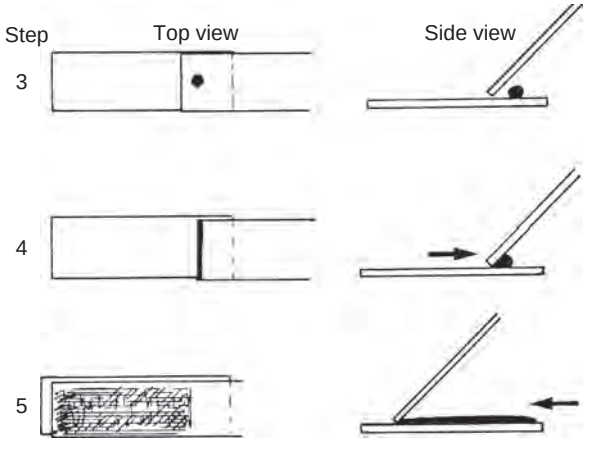

Figure 28-2 Preparing a blood smear (see text). When the second slide touches the drop on the first slide, surface tension will cause the drop suddenly to spread out all along the length of the touching slides.

Red Cells

The red cell number has already been implicitly measured by estimating the hematocrit from the nail beds and conjunctiva. Keep in mind such estimates of anemia and polycythemia when attempting to estimate the white cell count and platelet count from the relative numbers of cells on the smear (*vide infra*).

The diameter of the normal red cell is approximately the same as the nucleus of a small lymphocyte.

Information about red cell size can also be obtained from the mean corpuscular volume (MCV), which the electronic cell counter determines by displacement of an electrolyte solution, provided that there is no elliptocytosis, rouleaux formation (*vide infra*), or cold agglutinins (Rappaport et al., 1988). (In fact, the electronic cell counter's measurement of MCV is more accurate than the hematocrit; the latter is not measured but rather calculated from the MCV and the red cell count, giving an error of 3% to 5% compared with the spun hematocrit.)

Considerable variation in the shape of the red cells (poikilocytosis) is a significant finding, not available from an inspection of the electronic hemogram. Abnormal cells include drepanocytes (also called *banana cells* and *sickle cells*), spherocytes, microspherocytes, stomatocytes, elliptocytes, burr cells, spur cells, helmet cells, bite cells, teardrop cells, basophilic cells, and schistocytes. Cabot rings, Howell–Jolly bodies, malarial parasites, nucleated red cells, and so forth are examples of red cell inclusions that cannot be detected without inspecting the smear.

Rouleaux formation is the appearance of the red cells as rolls or "stacks of coins." A normal phenomenon in the thick portion of the smear, rouleaux formation is "called" only in the thin part of the smear and therefore requires much experience. It results from changes in the surface charge of the red cells due to coating with increased amounts of globulin. Dr Eugene Robin once diagnosed a case of multiple myeloma from noting the rouleaux formation and so can you.

Cold agglutinins can also cause rouleaux formation on slides prepared in the customary manner. This can be diagnosed with confidence if such rouleaux are not seen on a second slide made from blood kept warm through the smearing and fixing stages, as with an incandescent lamp.

Anisocytosis is an abnormal variation in the size distribution of the red cells.

Unless your electronic counter has an accurate measure of the size distribution of the red cells (red cell distribution width [RDW]), one would not know whether the patient had a dimorphic population of red cells without examining the smear. If the electronic counter does provide both these measures (MCV and RDW), there is no need to make size estimates from the smear, except to learn how to do it against the day when such a device might not be available. (The same principle applies, although unstated, to the other tests in this section.)

One source of excellent slides of blood cells is the online pathology lectures, online pathology lectures, www.medicalschoolpathology.com/, by Dr John Minarcik (see "Red Blood Cells and Bleeding Disorders" and "Diseases of White Blood Cells, Lymph Nodes, Spleen, and Thymus"). For extensive material on histopathology, with videos, questions, and narrations, see www.medicalschoolpathology.com/HistoPathLabx.htm.

White Cells

With practice, one can estimate the white blood cell (WBC) count from the peripheral smear, if one has estimated the hematocrit.

An Arneth *lobe count*, looking for hypersegmented polymorphonuclear leukocytes, is performed by counting only those lobes that are seen to be connected by a thin thread of chromatin, not those that are simply overlapped. In counting 100 to 200 cells, one only need see 5% five-lobed polymorphonuclear leukocytes to know that an abnormality is present. If you find a single six-lobed polymorphonuclear leukocyte, you can stop counting instantly.

The causes of hypersegmented polymorphonuclear leukocytes are well known and are found in standard texts, with two important exceptions.

1. The most common cause of hypersegmented polymorphonuclear leukocytes in the present hospital population is the uremic syndrome. This is immediately reversed by the administration of supplemental folate, even though pretreatment serum folate levels may have been borderline or even normal (Siddiqui et al., 1970).
2. Patients with severe iron deficiency may have hypersegmented neutrophils that disappear with iron therapy. It is likely that iron deficiency inhibits formiminotransferase, thus producing a functional folate deficiency despite normal levels of folate in both the serum and red blood cells (Beard and Weintraub, 1969).

A *Barr body* is a tiny projection from the nucleus, which is thought to represent the "extra" X chromosome in female cells. Males may appear to have Barr bodies on up to 5% of their neutrophils. More than 10% of leukocytes from women (genotype XX) will have Barr bodies. Although the Barr body has been likened to a drumstick (with the thick part distal to the nucleus proper), many XY nuclei will have drumsticks. A true Barr body looks more like a lollipop or a balloon on a stick.

The payoff for examining blood smears is to find the 1 of 600 phenotypically male patients whose hypogonadism is suddenly explicable based on the XXY chromosomes of Klinefelter syndrome.

Döhle bodies are pale blue inclusions seen in Wright-stained polymorphonuclear leukocytes. By histochemical analysis, they are composed of ribonucleoprotein and/or ribonucleic acid. Once thought to be diagnostic of scarlet fever, they appear in the blood of 7% of hospitalized patients, specifically in the conditions listed in Table 28.1. They are not seen in healthy student nurses (Abernathy, 1964, 1966) or patients with urticaria or serum sickness (Granger and Pole, 1913).

Döhle bodies with red granules within them are called *Amato bodies*. These have the same significance as Döhle bodies, although they too were once thought to be diagnostic of scarlet fever (Toomey and Gammel, 1927).

Structures identical to Döhle bodies in light microscopic appearance have also been seen in various congenital syndromes, including the May–Hegglin anomaly, Chédiak–Higashi syndrome, the pseudo-Pelger–Huet syndrome, the Fechtner syndrome, and so forth (Peterson et al., 1985).

Auer rods are pink (by Wright stain) intracytoplasmic rods or clumps that come from the azure granules that in turn come from lysosomes.

TABLE **28.1** *Döhle bodies: Associations*

	References
Infections	
Scarlet fever (100% to first 2 days)	(Granger and Pole, 1913)
Tuberculosis (11% to "practically all")	(Bachman and Lucke, 1918)
Lobar pneumonia (67%–100%)	(Bachman and Lucke, 1918)
Empyema	
Bronchitis	
Viral upper respiratory infection	
Pertussis (rare)	(Bachman and Lucke, 1918)
Amebiasis	
Purulent infections	
Erysipelas (64%)	(Granger and Pole, 1913)
German measles (rare)	(Bachman and Lucke, 1918)
Chicken pox (rare)	(Bachman and Lucke, 1918)
Measles (45% in the first 5 days)	(Granger and Pole, 1913)
Diphtheria (68% in the first 5 days)	(Granger and Pole, 1913)
Tonsillitis (58%)	(Granger and Pole, 1913)
Typhus	
Neoplastic	
Carcinoma	
Myelogenous leukemia	
Lipoma	
Myoma	
Neurologic	
Concussion	
"Anxiety neurosis"	
Other	
Diabetes	
Uremia	
Anemia	
Severe burns	
Pregnancy	(Abernathy, 1966)
Iatrogenic	
After the infusion of diphtheria toxin	
After blood transfusion	
After cyclophosphamide treatment	

From Abernathy MR. Incidence of Döhle bodies in physiologic and pathologic conditions. *Lab Digest.* 1964;28:3–5 and Abernathy MR. Döhle bodies associated with uncomplicated pregnancy. *Blood.* 1966;27: 380–385, with permission.

They are most frequent in immature cells. They were discovered by Auer, who reported seeing them in lymphocytic leukemia (Auer, 1906), and this continues to be reported (Juneja et al., 1987). Both reported seeing Auer rods in tuberculosis in 1913 (Freeman, 1960), and this too has been replicated (Leavell and Twomey, 1964). They are seen in 21% of acute myelogenous leukemia patients, or 66% to 75% if peroxidase staining is used (Jain et al., 1987).

The *eosinophil* count obtained by multiplying the white cell count by the percentage of eosinophils is only accurate when the percentage of eosinophils is at least 5% to 6%, even if the white cell count is very high. Accuracy can be improved by counting 200 white cells instead of the usual 100.

The term eosinophilia refers to a count of more than 310 eosinophils per mm^3. The differential diagnosis of eosinophilia (which includes parasites, allergic conditions, some infectious conditions such as tuberculosis, malignant conditions, and a number of other causes, all diagnosable on other grounds) is out of fashion in most medical centers. Thus, there is little awareness of a frequent new cause of eosinophilia in the modern medical center—therapeutic radiation-induced eosinophilia (Ghossein et al., 1975).

Any degree of eosinophilia rules out the diagnosis of Cushing syndrome, and the absence of eosinophils rules out the diagnosis of chronic adrenocortical insufficiency.

Platelets

An estimation of platelet number should routinely be made from the smear, and the examiner's skill should be augmented by feedback from the electronic platelet count. Begin by estimating 25,000 platelets per mm^3 for every platelet seen in a high-power field.

Electronic cell counters may produce a spurious thrombocytopenia in three circumstances (Kjeldsberg and Hershgold, 1974): (a) platelet satellitism, which occurs in blood collected in EDTA as platelets adhere to polymorphonuclear leukocytes and are excluded by size from the count; (b) in the presence of platelet agglutinins, which can cause the platelets to clump together—the clump is also optically excluded by the counter because of its size; and (c) giant platelets, which are excluded for the same reason.

Spurious thrombocytosis may be produced by the electronic cell counter in three circumstances (Rappaport et al., 1988), all of which can be recognized on the smear: (a) fragmented white cells (smudge cells), as in leukemia or sepsis; (b) fragmented red cells, as in thrombotic thrombocytopenic purpura, disseminated intravascular coagulation, microangiopathic hemolytic anemia, or cardiopulmonary bypass; and (c) marked microcytosis of the red cells as in microspherocytosis. (Also see the "Rumpel–Leede Test" section in Chapter 7 and "Blood Clot Tests" above.)

Earlobe Histiocytes (Low Power)

In the *first* drop of blood (Smith, 1964) taken from the lanced earlobe of a patient with subacute bacterial endocarditis, it is often, but not always, possible to find large histiocytes, which are at least one and a half times as large as monocytes (Daland et al., 1956; Van Nuys, 1907). (This is an example of empiric but not scientific fact as we do not know why this should be true, only that it is.)

Sensitivity

In various large series, the sensitivity for subacute bacterial endocarditis has been reported as 21% to 33% (Hill and Bayrd, 1960; Smith, 1964).

False Positives

Earlobe histiocytes are not pathognomonic for bacterial endocarditis. If one uses strict criteria and requires at least 10% of the differential count to be these unusual cells, the differential diagnosis also includes malaria and trypanosomiasis.

Differential Diagnosis of Lower Counts of Histiocytes

Large histiocytes (also called macrophages) may constitute 2% of the differential count in septicemia, rheumatic fever with active carditis, tuberculosis, Hodgkin disease, chronic sinusitis, subsiding hepatitis, mediastinal tumor, agranulocytosis, localized bacterial infection (Smith, 1964), and systemic lupus erythematosus.

If one accepts 1% histiocytosis as evidence of a positive sign, one will start to include perinephric abscess, infectious mononucleosis, mastoiditis, ulcerative colitis, subsiding acute appendicitis, trichinosis, acute and chronic myelocytic leukemia, typhoid fever, paroxysmal nocturnal hemoglobinuria, cholera, severe hemolysis, transfusion reactions, chronic meningococcemia, sickle cell anemia (Greenberg, 1964), and anemia of the newborn (erythroblastosis fetalis) (Hill and Bayrd, 1960; Smith, 1964).

Large histiocytes may be found in normal persons but they never constitute more than 1% of the differential count (Hill and Bayrd, 1960; Smith, 1964).

Leukocytes Containing Bacteria

In patients with septicemia, a low-power scan of a thin blood film prepared from the first drop of earlobe blood and stained with Gram stain (or Jenner–Giemsa, Leishman, or May–Grünwald–Giemsa) may reveal intracellular organisms. The ear that the patient has *not* been lying on gives better results. The feathered edge of the smear is the best place to find the infected leukocytes.

Gram Stain of the Buffy Coat

Gram stain of the buffy coat is an incredibly simple technique (see later in this chapter for the Gram stain) that permits the identification of bacteria in the blood about 24 to 48 hours before the laboratory reports a positive culture, and rarely, in cases with negative culture results (Humphrey, 1944). See Table 28.2 for the diagnostic value of this technique (which has also been applied to the peripheral blood film and blood aspirated from skin lesions) in various studies. No studies have yet been reported giving a comparison of buffy coat staining with the earlobe histocyte test performed in the same patients.

In contaminated blood transfusion reactions, one should also Gram stain the *plasma* of blood centrifuged briefly (for 2 to 3 minutes; also see Ascitic Fluid, later in this chapter.)

Serum and Plasma

Distinguishing Hemoglobinuria from Myoglobinuria

Most urine tests for hemoglobin are also positive for myoglobin. Thus, given a positive dipstick test, how can one distinguish between prior hemoglobinemia and prior myoglobinemia?

Hemoglobin in the blood binds to haptoglobin. The molecular size of the hemoglobin–haptoglobin complex is too large to pass the glomerulus and appear in the urine, and only when the binding capacity of haptoglobin is exceeded will hemoglobin appear in the urine. Thus, any time that plasma hemoglobin spills into the urine, a simultaneous serum (plasma) sample will be mahogany in appearance and positive for hemoglobin by benzidine or other dipstick. (The hemoglobin can react with the dipstick even when bound to haptoglobin.)

Because myoglobin does not bind to haptoglobin to any significant extent, myoglobinuria can be distinguished from hemoglobinuria secondary to hemoglobinemia by the fact that the myoglobinuria will *not* be accompanied by pigmented, dipstick-positive serum (or plasma).

TABLE **28.2** *Results of studies examining blood film or buffy coat for bacteria*

Reference	Method	Sensitivity	Predictive value of a negative test	False positives
Brooks et al. (1973)	Buffy coat examined on 135 specimens sent for blood culture	5/14 (36%)	135/144 (94%)	0
Powers and Mandell (1974)	Buffy coat examined in 16 patients suspected of having endocarditis (6 of whom did not) and 6 normal controls	6/10 (60%)	12/16 (75%)	0
Smith (1966)	Earlobe blood of septicemic patients	17/57 (30%)		
Thomas (1943)	Examination of peripheral blood film in rapidly fatal cases of meningococcemia	6/12 (50%)		
Hoefs and Runyon (1985)	Ascitic buffy coat in spontaneous bacterial peritonitis	(55%)		
Bush and Bailey (1944)	Examination of peripheral blood film in rapidly fatal cases of meningococcemia[a]	3/6 (50%)		
McLean and Caffey (1931)	Examination of blood film obtained from hemorrhagic purpuric lesion in meningococcemia	15/18 (83%)		

[a]The patients with organisms seen on peripheral smear all had negative blood cultures. The cells containing the Gram-negative diplococci superficially resembled basophils.

The Schumm Test

The Schumm test is for methemalbumin, which appears acutely in the plasma following any episode of hemoglobinemia. The test requires a decent student laboratory, a hand spectroscope, and a sunny day (the light source for the spectroscope).

Method

Cover 9 volumes of plasma with a 1-volume layer of ether. Add 1 volume of concentrated ammonium sulfide to the plasma layer (*beneath* the ether) with a pipette. Stir all the components together, and examine for a sharply defined band at 558 nm.

Salicylate Intoxication

A rapid approximation of serum salicylate levels may be obtained with Phenistix (see later in this chapter). The dipstick turns brown at concentrations up to 40 mg per dL and purple at concentrations over 90 mg per dL (Clarkson, 1978).

Viscosity

A viscometer for studying a patient suspected to have the hyperviscosity syndrome may be made from a red cell or white cell diluting pipette or even from the barrel of a tuberculin syringe (sans plunger).

Fill the container with the serum to be tested, and determine the time it takes to drip out. Compare the number of elapsed seconds with a control. In hyperviscosity syndrome, the value is usually twice the normal.

Cryoglobulins

Cryoglobulins are globulins precipitable by cold. They occur in (a) multiple myeloma, (b) a variety of "collagen-vascular" diseases and other entities characterized by circulating antigen–antibody complexes, and (c) polyclonal hypergammaglobulinemia such as that caused by cirrhosis of the liver. They are sometimes found accidentally by the clinical laboratory when a serum sample stored in the refrigerator for later analysis is found to have "coagulated."

Cryofibrinogen is fibrinogen that is precipitable by cold. Cryofibrinogens are found as accompaniments to many inflammatory diseases and some tumors and rarely as a primary disease. They are rarely found accidentally by the clinical laboratory as they are not present in serum and most refrigerator-stored samples are not plasma.

Because the test is so simple (and because many laboratories will respond to a request for cryoproteins by performing the tests for cold agglutinins or cold hemolysins, which are unrelated), the method is presented here.

1. Put a plasma sample and a serum sample in the refrigerator.
2. Look at the two tubes the next morning. Tilt them. Is there a solid gel at the bottom? If there is a gel in both tubes, one is dealing with a cryoglobulin. If there is a gel only in the bottom of the plasma tube, one is dealing with a cryofibrinogen.

The Sia Water Test

The Sia water test for abnormal quantities or types of globulins is now performed by adding one drop of serum to a 30-cm cylinder of distilled water. Normally, when the serum hits the water, there is no change in the appearance of the water. When the test is positive, however, there will be an opacity in the shape of a tear or an upside down parachute as the serum falls through the water.

This test was invented in China for diagnosing the hyperglobulinemia of kala azar. Originally, 20 mL of serum was shaken with 0.6 mL of distilled water and turbidity was read at 5, 15, 30, and 60 minutes (Sia, 1924).

Some persons perform the test by putting a drop of distilled water into the serum and some put a drop of serum into a short test tube full of distilled water.

According to the loose criterion, *any* degree of turbidity is a positive test. Using this criterion, the test is 12% to 20% sensitive for myeloma protein (Laurell and Waldenstrom, 1961; Pruzanski and Watt, 1972) and 57% sensitive for macroglobulin (Laurell and Waldenstrom, 1961). Proteins migrating in the α and β range almost always give a negative test. False positives occur in some normal persons.

According to the strict criterion, flocculation must occur as soon as the serum falls into the water. This is called a "3+ test." It requires that the M-component be 2.4 g per dL or higher but eliminates the false positives occurring in normal persons. However, this result is generally seen only in about 25% of patients with macroglobulinemia (Laurell and Waldenstrom, 1961).

Lipids

To make a quick determination of the type of hyperlipoproteinemia (if any) that a patient has, allow a serum sample to sit overnight in the refrigerator.

In the rare type I hyperlipoproteinemia, there will be a creamy supernatant over a clear infranatant. (Such blood may look like cream of tomato soup as it is drawn.) Type II hyperlipoproteinemia is the only type in which the serum may look perfectly normal. However, some type IIB sera will develop a cloudy or turbid infranatant. The rare type III will have a creamy supernatant and a cloudy or turbid infranatant. Sometimes, these separate poorly by the next morning and simply appear cloudy throughout. The common type IV will have a clear supernatant and a turbid infranatant, or sometimes will be cloudy throughout if separation has been poor. Because type V is a combination of types I and IV, a creamy supernatant over a turbid infranatant is expected.

Further analysis can be done by electrophoresis or cholesterol and triglyceride ratios, but these are beyond the scope of this book.

Although the above is not foolproof, it offers an excellent chance of making a very quick diagnosis after very little effort, especially if one correlates the findings with the xanthomas discussed in Chapter 7.

Ketoacidosis and Hydroxyacidosis

The ubiquity of the autoanalyzer has made it possible for ketoacidosis (due to acetoacetate) and hydroxyacidosis (due to hydroxybutyrate and/or lactate) to be diagnosed in the aggregate along with the other causes of anion gap acidosis.

At the same time, there has been less interest in measuring serum acetone (expressed in terms of the weakest dilution—1:2 *n*—that gives a positive reaction with Acetest tablets). This test also measures acetoacetate, but not the hydroxy acids.

As each 1:1 dilution of serum that is required to reach a negative test for acetone represents about 4 mEq per liter of acid

(3 of hydroxybutyrate and 1 of acetoacetate), it would seem that one could determine whether all of the anion gap had been accounted for. Alas, the redox pair (acetoacetate/hydroxybutyrate) shifts toward the latter (unmeasured) hydroxy acids in situations of greater acidosis. Thus, an improvement in patients with diabetic ketoacidosis, for instance, may be accompanied by an improvement in all biochemical parameters except for serum acetone, which becomes positive in even stronger dilution although the total amount of the redox pair is reduced.

A bedside test for β-hydroxybutyrate would be extremely helpful in this regard because one could determine the exact ratio at any given moment in any given sample and know whether the anion gap had been adequately explained or whether it would be necessary to measure lactate or even whether there was a simultaneous but masked decreased anion gap.[2]

It has been stated that the addition of a drop of hydrogen peroxide to a serum sample containing β-hydroxybutyrate would convert the latter to acetoacetate. Then the difference between the acetoacetate titration with and without added hydrogen peroxide would give the level of hydroxybutyrate. (This seems to be based on the decades-old Hart test for β-hydroxybutyrate in the urine, which involved studying a diluted sample that had also been treated with heat and glacial acetic acid.)

Unfortunately, the test does not work in the suggested form on serum as the addition of the hydrogen peroxide interferes with (i.e., "bleaches") the color development of both the tablet and dipstick currently used to assay for "acetone."

Osmolal Gaps

The osmolal gap[3] is the difference between the measured osmolality and the following quantity: $2(Na^+ + Cl^-)$ + BUN/2.8 + blood glucose/18.

Osmolal gaps greater than 10 mOsm per kg are found in cases in which the following substances have appeared in the serum: methanol, ethanol (divide the osmolal gap by 4.24 to obtain mg per dL of ethanol), isopropyl alcohol, acetone, ether, trichloroethane, glycerin, isoniazid, diatrizoate, mannitol, sorbitol, and some solutions infused for the treatment of shock (Smithline and Gardner, 1976).

Urine

Color

Unusual colors in the urine may result from the metabolism of both endogenous and exogenous substances (Table 28.3). A detailed history is most important, but measuring the urine pH, observing for color change on standing, and certain other tests may be useful (Raymond and Yarger, 1988). (See the tests described later in this chapter for hemoglobinuria and porphyrins and the ferric chloride test.)

Specific Gravity

The osmolality of the urine can be estimated from the specific gravity. Given a standard diet, every increase of 0.003 in the specific gravity is about 100 mOsm of solutes. To correct for glucosuria, subtract 0.004 from the specific gravity for 1% sugar (which is 270 mg per dL, or 2+ to 3+ depending upon the brand of dipstick). To correct for 3+ proteinuria (which represents about 1 g per dL), subtract 0.003. The remaining specific gravity is that due to solutes. These conversions work *only* for urine.

In studies done by Dr Holly Sata of California, the dipstick specific gravity varied from the hydrometer value by an average of 0.005 unit and was not good enough to rely on in individual cases. (Using the conversion formula given above, the hydrometer gave a better estimate of measured osmolality than did the dipstick.)

The dipstick specific gravity was found to respond correctly to monovalent salts but not to glucose or urea; protein was overestimated. A pH change from 5 to 7 further decreased the specific gravity reading by as much as 0.10 unit (Kirschbaum, 1983).

Although it is clearly optimal to measure the osmolality, if the measurement is not available, the specific gravity should be measured with a hydrometer or refractometer.

Chemistry

Hemoglobin and Myoglobin

As noted earlier in this chapter, hemoglobinuria secondary to hemoglobinemia is characterized by benzidine-positive material, usually of a mahogany color, in both plasma and urine. Hemoglobinuria secondary to bleeding into the urinary tract with no prior intravascular hemolysis (hemoglobinemia) is characterized by clear serum and residual unhemolyzed red cells seen on microscopic examination of the urine. Myoglobinuria from myoglobinemia is characterized by clear serum and benzidine-positive pigment in the urine with few or no red cells seen on microscopic examination.

Porphyrins

Bedside Porphyrin Metabolism

All diseases that may be accompanied by the excess production of porphyrins can be divided into two classes: the porphyrinurias and the true porphyrias. The former include diseases such as lead poisoning, cirrhosis, malignancies, hemolytic anemias, and a variety of other conditions. However, one does not screen these patients for urinary porphyrins for two reasons: First, the production of measurable quantities of porphyrins in the urine of these patients is so inconstant (with the possible exception of lead poisoning) that the test is not useful as a diagnostic screen. Second, there are other easier ways to screen for these diseases. They are mentioned here only because they may give false positives in the tests to be described.

The true porphyrias, on the other hand, are not as easily diagnosed, and here the determination of urinary porphyrins (for porphyria cutanea tarda), as well as red cell porphyrins and fecal porphyrins (for some of the very rare inherited porphyrias)

[2] A decreased anion gap occurs with (a) elevation of an unmeasured (or unconsidered) cation (potassium, calcium, lithium, or magnesium); (b) decreased albumin; or (c) increased abnormal globulins.

[3] Dr Al Shapiro of Pennsylvania asked technician applicants to distinguish between osmolality and osmolarity. There is no practical difference with the usual biologic fluids because the density of water is 1 g per cc under customary conditions. Purists who like challenges are invited to reconcile the definitions given in the 24th edition of *Dorland's Illustrated Medical Dictionary* with those of Homer Smith (1956).

TABLE **28.3** *Urine color*

Color of urine	Substance
Pink	Hemoglobin, myoglobin
Pink to red	Beets, oxyhemoglobin, doxorubicin, ibuprofen, phenytoin, phensuximide
Pink to red in large concentrations	Porphyrins
Pink to red in alkaline urine	Phenolphthalein, phenolsulfonephthalein, bromsulfalein, santonin
Pink to red in acid urine	Urorosein
Pink to red on contact with hypochlorite bleach	Aminosalicylic acid
Deep red after large doses	Antipyrine
Red if excreted in large amounts	Congo red
Red	Pyridium, indirubin from malabsorption (Sapira et al., 1971)
Red-orange	Rifampin
Red-brown	Porphobilin, chloroquine, ibuprofen, phenothiazines, phensuximide, phenytoin
Red-brown in alkaline urine	Levodopa, methyldopa
Red-violet in acid urine, yellow-brown in strongly acidic urine	Chrysophonic acid formed from anthracine (aloe, cascara sagrada, rhubarb, senna)
Blue or green (the latter possibly due to mixture with yellow of urine)	Methylene blue, chlorophyll breath mints, magnesium salicylate, Doan's pills, iodochlorhydroxyquin, pyocyanin from *Pseudomonas*
Blue	Indigotin ("blue diaper disease") (Sapira et al., 1971)
Blue or blue-green	Mitoxantrone *(Med Lett Drugs Ther*, 1988)
Purple	Chlorzoxazone
Purple in alkaline urine	Phenolphthalein
Greenish tint	Thymol
Olive green to black on exposure to air	Phenol
Deep yellow in acid urine	Santonin
Yellow to brown	Bilirubin, sulfamethoxazole, nitrofurantoin, primaquin
Yellow-orange	Carrots, vitamin A, aminopyrine, warfarin
Yellow-orange in alkaline urine	Sulfasalazine
Yellow to amber	Urobilin
Light brown to dark brown	Methemoglobin
Brown, black (or pink)	Myoglobin
Black on standing	Homogentisic acid
Brown to black on standing	Melanin pigment or precursors

From Ham TH, Shwachman H, Hills AG. Proteins of plasma and serum—sedimentation rate of red cells. In: Ham TH, ed. *A Syllabus of Laboratory Examinations in Clinical Diagnosis*. Cambridge, MA: Harvard University Press; 1957 and Raymond JR, Yarger WE. Abnormal urine color: Differential diagnosis. *South Med J.* 1988;81:837–841, with permission.

becomes useful. (Acute intermittent porphyria, one of the most common causes of undiagnosed recurrent abdominal pain, is best diagnosed by testing for porphobilinogen, *vide infra*.)

Screening for Urinary Porphyrins

The following protocol is after Snapper and Kahn (1967).

1. Add 25 mL of 10% NaOH to 75 mL of hemoglobin-free urine in a glass cylinder and let it stand overnight.
2. If the precipitate is white the next morning, the test is negative. If it is brown, however, porphyrins are present or the patient has taken cascara. (Shining a Wood light on the precipitate will produce a red fluorescence in either case.)
3. Redissolve the precipitate in 10% HCl and examine under the Wood light. If the red fluorescence is present, porphyrins of some type are in the sample and further study is mandatory. (The red fluorescence of cascara disappears in 10% HCl.)

Other Fluorescent Tests for Porphyrins

1. A reagent for extracting porphyrins from urine or stool may be made from 4 parts of ethyl acetate (or amyl alcohol) and 1 part

glacial acetic acid. Add 1 volume of this mixture to 2 volumes of the substance to be studied; shake. Examine the tube with a Wood light for red fluorescence.
2. (This reagent may be improved and adapted to blood testing by adding some ether. However, the latter is so hard to find at present that alternatives are suggested below. Additionally, if you are thinking about erythropoietic porphyrias, you are beyond the screening stage.)
3. For fecal porphyrins, just smear the feces from the rectal examination onto a piece of filter paper, cover with acetic acid, and search for red fluorescence with the Wood light.
4. For red cell fluorescence, use the fluorescent microscope in the pathology department to examine an *unstained* blood smear, as well as a control smear, for fluorescence, being sure that the excitation and emission filters are set correctly. *Under no circumstances should you attempt to improvise a fluorescent microscope* by shining a Wood light through the microscope as this could damage your eyes.

Urine Porphobilinogen Tests

The purpose of urine porphobilinogen tests is to detect porphobilinogen in the urine of patients suffering from acute intermittent porphyria. They are not used to detect any other porphyrias or porphyrinurias.

The Watson–Schwartz test is performed as follows:

1. Shake about 5 mL of urine with the same volume of Ehrlich's urobilinogen reagent. (This can be found in most clinical laboratories, which purchase it premixed from commercial suppliers. If you have to make your own, add 600 to 700 mg of *p*-dimethylaminobenzaldehyde to 150 mL of concentrated hydrochloric acid [HCl] and top it off with distilled water to make a total volume of 250 mL.)
2. If a red or pink color occurs, you have detected something, possibly only urobilinogen. Add an equal volume of saturated sodium acetate solution.
3. Add some chloroform and shake. Eventually two layers will emerge. (This may take some time if you shake too violently. However, you must shake vigorously enough to allow the red pigment to partition between the two phases. If in a hurry, simply centrifuge for a minute in the urinalysis centrifuge.)
4. If the pigment is predominantly in the chloroform layer (the one at bottom), the test is positive for urobilinogen not porphobilinogen. If the pink color remains in the aqueous (upper) phase, however, you should do one more extraction to remove interfering substances. Pour some of the upper phase into another tube, and extract against toluene or butanol. If the pigment still remains in the aqueous phase, you may make a provisional diagnosis of acute intermittent porphyria.

Significance. A single false-negative Watson–Schwartz test was found in an asymptomatic member of a large kindred (Mahood and Killough, 1966). The false-positive rate was 0.0% in a series of 1,000 consecutive urines, if the butanol extraction step was used. Without this step, the false-positive rate was 5.9% (Townsend, 1964). Purple false positives (due to indoles) may be obtained in the carcinoid syndrome and from compliant patients receiving at least 750 mg per day of methyldopa.

The Watson–Schwartz test was superior to the Hoesch test (*vide infra*) when performed in Dr Watson's laboratory (Pierach et al., 1977), but in all fairness, the Hoesch test has its champions.

The Hoesch test is an alternate that circumvents the problem of false positives due to urobilinogen, pyridium therapy, and (one hopes) all the other contaminants to which urine is heir. No extraction need be done. However, one cannot appropriate the clinical laboratory's urobilinogen reagent, but must make up some of Ehrlich's original reagent, by dissolving 2 g of *p*-dimethylaminobenzaldehyde in 100 mL of 6 N HCl. Place a few milliliters of fresh urine in a test tube and add about two drops of the reagent. A red color is porphobilinogen (Lamon et al., 1974).

Bence Jones Protein

A Method

1. Check the pH of the urine with a pH meter or pH paper. If it is above pH 5, add acetic acid or acetate buffer to bring the pH to 5.
2. Place the urine in a water bath at 40°C and raise the temperature of the water bath. When the temperature of the *urine* is between 40°C and 60°C, a precipitate or flocculence or murkiness will develop if Bence Jones protein is present (but the precipitate may not immediately collect at the bottom of the tube).
3. Snapper adds an equal volume of 4% sulfosalicylic acid at this point, bringing the pH to 3. This precipitates not only all the Bence Jones protein, but also any albumin that is present. (You already know whether albumin is present because it will show as protein on the dipstick but Bence Jones protein *will not*.)
4. Now boil the urine. Bence Jones protein will dissolve but albumin will not. If you are uncertain about the results, pour the boiling urine through filter paper, which will retain the denatured albumin but not the dissolved Bence Jones protein. Put the filtrate into an ice bath and when it cools down to about 50°C, you will be able to see the Bence Jones protein precipitate again.

Historic Note

Some famous places do not even have a student or house staff laboratory. Those that do have a laboratory may not have a water bath or even a thermometer. Accordingly, the following quick and dirty method has been invented. It requires no reagents or equipment, although the astute will be able to improve it to the degree that such are available to them.

An Alternate Method

1. Place the patient's fresh (and hence acidic) urine into a test tube. (If urine is allowed to stand, bacteria will grow and may make the urine alkaline.) If the urine contains albumin, it must first be removed by precipitation and filtration as above.
2. Place the test tube in a beaker about half the height of the test tube so that some of the urine can be seen above the level of the beaker.
3. Place a piece of a telephone directory page or newspaper into the beaker so that part of it may be read *through* the urine in the test tube, unobscured by the additional glass wall of the beaker.
4. Place the whole thing in a microwave oven, turn it on, and wait for the urine to boil, as you observe through the door of the microwave. If Bence Jones protein is present, one can often observe a turbidity in the tube before the urine boils. By the

time the urine boils, the turbidity will have cleared, although not always completely. (The degree of turbidity is judged by the ease of reading the newspaper print through the urine.)

Urinary Catalase

A Method

The following method (Gagnon et al., 1959) is recommended for its simplicity.

1. Soak a disk of Schleicher and Schell 507-GH filter paper in one or two drops of urine and then place it in a 16-mm test tube to which 5 mL of 3% hydrogen peroxide are added. (Obviously, the disk has to be smaller than the diameter of the test tube.)
2. Observe whether the disk floats to the top. Allow 45 minutes before calling the test negative.

Interpretation. Normally, the disk does not float. However, if catalase appears in the urine, it will catalyze the formation of water and oxygen from the hydrogen peroxide solution. The oxygen bubbles attach to the paper disk and cause it to float. Obviously, the speed of flotation is proportional to the catalase concentration of the urine.

Catalase can appear in the urine when renal parenchymal cells are destroyed, when red or white cells appear in the urine, or when there is proliferation of the 90% of bacteria that cause pyelonephritis and also produce catalase. (The 10% that do not produce catalase, such as enterococci, may still produce a positive catalase test because of leukocyturia.) The catalase test may even be positive when routine urine cultures are negative, as during protoplast formation (Braude and Berkowitz, 1961; Sapira and Shapiro, 1967), or when the microscopic examination is negative because of lysis of the red and WBCs.

The Ferric Chloride Test and Phenistix

A 10% solution of ferric chloride shaken with an equal volume of urine will react slowly with a wide range of phenols and related materials. It takes about 2 minutes for a maximum color change to occur (Cassidei et al., 1978). Salicylates produce a brown color at a concentration of 25 to 50 mg per dL and a purple color at concentrations greater than 150 mg per dL. In the presence of 5-hydroxyindoleacetic acid from carcinoid syndrome (Yamaguchi and Hayashi, 1978) or desferrioxamine (Finlay, 1978), a deep red-brown color develops. Acetoacetate gives a purple color and phenylpyruvic acid a gray-blue color when it occurs in the quantities seen in phenylketonuria (Broder, 1987).

Phenistix, which are reagent strips impregnated with ferric chloride, were once used in screening for phenylketonuria but have been replaced because of false negatives (Medical Research Council Steering Committee, 1981). However, the sticks (if available) can still be used in lieu of the ferric chloride solution for the purposes mentioned above.

Very high doses of phenothiazines may mimic the reaction given by salicylates but can be differentiated by adding a drop of concentrated sulfuric acid to the reagent strip. This strong acid bleaches out the color due to salicylates but intensifies that due to phenothiazines (Clarkson, 1978).

Forrest Reagents for Psychoactive Drug Overdose

In the early 1960s, psychoactive drug compliance was a major question facing psychopharmacologists. A series of papers by Forrest and Forrest in *Clinical Chemistry and The American Journal of Psychiatry* gave formulas for solutions that turned color when shaken with an equal volume of urine containing various psychoactive drugs, the intensity of the color being proportional to the concentration of the substance. Although these solutions became obsolete for this purpose in the 1970s, they still have great potential for diagnosing drug overdose in the emergency room. Two that I have found useful are as follows:

1. Universal reagent for the detection of high-dose phenothiazines:
   5 parts 5% ferric chloride
   40 parts 20% perchloric acid
   50 parts 50% nitric acid
   Shake with urine and check immediately for a purple color.
2. Imipramine reagent:
   Equal amounts of
   0.2% potassium dichromate
   30% sulfuric acid
   20% perchloric acid
   50% nitric acid
   Shake with urine and read the green color.

False negatives are found with the simultaneous ingestion of ascorbic acid (James et al., 1980).

The pharmaceutical manufacturing association has outstripped "shake" chemistry; it is not known what other current psychoactive drugs will react with these reagents. Could you think up a good senior research project?

Microscopy

Preserving Wet Mounts of Urine and Other Fluids

From time to time, an attending physician will wish to review a joint fluid, a urinalysis, or some other wet mount the morning after it was examined.

A Method

If the histology department is not open and glass sealant cannot be obtained, simply place a coverslip over the fluid and seal the edges with fingernail polish.

If a specific finding has been noticed but its position cannot be noted because the microscope has no coordinates, simply take a wax crayon and mark the bottom of the slide in the beam of the light so that the interesting field can be quickly relocated. Never mark the top of the slide, especially if it is a Gram or an acid-fast stain.

You may be able to obtain a Field Finder slide. This is simply a glass slide, the same size as the standard microscope slide, with an imprinted grid. This can be placed on top of the examined slide. Each square of the grid has an identifying number visible under the microscope but not interfering with the view. (If the specimen slide does not have a frosted labeling surface, be sure to mark an end for orientation.)

The Three-Glass Test

In males, the microscopic examination of the urine for pus can be made more diagnostic by collecting the specimen in three glasses or containers. The stream is started in the first container, then moved to the second container, and then completed in the third container, all without stopping the stream.

In urethritis, the pus is predominantly or exclusively in the first glass; in prostatitis, the pus is in the first and third glasses; and in bladder and kidney infections, the pus is in all three glasses.

Crystals

Calcium oxalate dihydrate crystals (Fig. 28-3) occur in normal urine. These crystals resemble little diamonds and in three dimensions are actually octahedrons (double pyramids, placed base to base). They *may* also be seen in the urine of patients with ethylene glycol intoxication.

If the oxalate is excreted in the form of calcium oxalate monohydrate, it may appear in the form of uratelike needles and other thin crystal forms, as shown on the left in Fig. 28-3. These have in the past been called "hippurate crystals." In ethylene glycol poisoning, they may occur in huge numbers, alone or mixed with the calcium oxalate dihydrate octahedrons (Terlinsky et al., 1981).

Urate crystals (in acid urine) and phosphate crystals (in alkaline urine) are not helpful. They can even be predicted from the urine pH.

Red Blood Cell Casts

In an unstained urine, red cell casts appear as orange translucent casts, the same size and shape as the more frequently seen types of casts. They are not red, like red cells, but clearly orange. Once seen, they will never be confused with anything else.

The presence of red cell casts signifies glomerulitis (glomerulonephritis, antigen–antibody complex disease as in infectious endocarditis, etc.) until proven otherwise. They may also be seen in bleeding into the lumen of the nephron as in polycystic kidney disease. They are *never* normal.

Fat Embolization

Fat embolization is often accompanied by fat droplets in the urine, which may be detected with any supravital fat stain, such as Sudan III (see also later in this chapter).

Oval Fat Bodies

Oval fat bodies are degenerative tubular cells that have sloughed into the urine. In some, but not all, patients with nephrotic syndrome there is a hyperlipoproteinemia causing the tubular cell, through incompletely understood mechanisms, to undergo fatty degeneration. When this fat crystallizes inside the sloughed cell, an oval fat body is created. This can be identified with a fat stain such as the Sudan III stain (discussed under stool fat stains later in this chapter), or more simply with a pair of polarizing lenses (which can be carried in one's wallet).

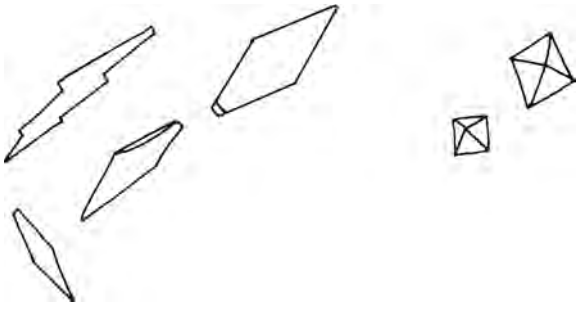

Figure 28-3 Calcium oxalate crystal in urine (see text). The monohydrate of ethylene glycol poisoning is at the left, and the dihydrate is shown on the right.

A Method (Polarized Light)

1. Obtain two polarizing lenses. These are simply two squares of polarizing paper, two pieces of polarizing glass, or two glass polarizing lenses (obtainable from American Optical). In dire straits, the two lenses from a pair of polaroid sunglasses can be used.
2. Check that these are in fact polarizing by looking through them *en face* at a light source. As you rotate one on the other through 90 degrees, there will be a change from complete transmittance of light to total black.
3. Place one of these lenses on top of the light source of the microscope below the condenser. This lens is called the "polarizer."
4. The other lens, called the "analyzer," can be placed anywhere between your eye and the stage containing the slide with the sample. In some microscopes, it is possible to disassemble the eyepieces and place the analyzer into the barrel of the scope. (This has the advantage of leaving your hands free and of polarizing both eyepieces of a binocular microscope.) However, if this is not possible, you can always simply hold the analyzer between your eye and one of the eyepieces and rotate it to see the light intensity change as before. (The change will not be complete because the light coming to your other eye through the other eyepiece is not passing through the analyzer.)
5. Turn the analyzer so that the field is very dark and the outline of cells can just barely be seen. Now scan the slide rapidly. Oval fat bodies, if present, will appear as bright lights, as will a lot of other refractile material that can be found in the urine.

   If you think an oval fat body is present, rotate the analyzer. As the field becomes lighter, the oval fat body (or other refractile material) will be less bright; but as the field becomes darker, the oval fat body becomes lighter and brighter.
6. Focus on the suspected oval fat body. If it truly is an oval fat body, you will see four bright bands radiating out from the center in alternation with four dark bands. The bright bands will emerge from the center at right angles to each other, forming what is called a *Maltese cross* in medicine. (In heraldry, it is actually a formée cross [Webster, 1976], as the true Maltese cross has notched ends and the oval fat body does not.)
7. Any other small round crystal can give a false positive. Starch granules from surgical gloves are such good false positives that they can be used for teaching polarizing microscopy. Simply put some on a glass slide and follow the steps above[4]

[4] With the increasing use of starched gloves during procedures, this false positive has become a real problem (Kirkpatrick and Sirmon, 1989). The real oval fat bodies, however, occur in renal tubular epithelial cells, whereas the starch granules do not. Second, the starch granules, but not the oval fat bodies, will turn gray in unpolarized light if exposed to a drop of iodine solution (e.g., from the Gram stain kit). Finally, if one focuses up and down on the four arms of the cross, they will go in and out of focus simultaneously in the case of an oval fat body, but will focus asynchronously with this maneuver in the case of most starch granules.

8. This technique can also be used for crystals (see Joint Fluid Crystals; *vide infra*).

"Telescoped Urine"

The term *telescoped urine* has nothing to do with the optics of the telescope or a "far away" appearance to the urine but rather to the mechanics of the old collapsible telescope or spyglass. It refers to urine in which the acute, subacute (if there is such), and chronic stages of a renal disease are all collapsed in time into the same urine sample. For example, the red cells and red cell casts of acute glomerulitis may accompany the broad, wide casts of chronic renal disease. "Telescoped urine" means that the patient has both acute and chronic renal failure.

Urinary Eosinophilia

Urinary eosinophilia was first advanced as a test for allergic interstitial nephritis but has been faulted on two grounds: the absence of perfect diagnosticity and the relative inefficiency of Wright stain compared with the Hansel stain (Nolan et al., 1986).

Using the Hansel stain and accepting even 1% eosinophils as a positive test for eosinophilia, the differential diagnosis includes allergic interstitial nephritis, other acute interstitial nephritides, chronic interstitial nephritis, transplant rejection, rapidly progressive glomerulonephritis, eosinophilic cystitis, and (rarely) prostatitis. The test has been negative to date in acute bacterial pyelonephritis and acute tubular necrosis.

Other Body Fluids and Secretions

Joint Fluid Crystals

A Method

1. Place the joint fluid on a clean glass slide and cover it with a cover glass. (If it is to be saved, it should also be sealed as described later in this chapter.)
2. Next search for crystals using polarized light (as described above).
3. If crystals are found, it will next be necessary to determine whether they are positively or negatively birefringent. This requires a first-order red compensator, which may be made quickly and cheaply as follows: Take a clean glass slide and put two layers of *good*-quality transparent tape in sequence on top of the slide. From below to above, you now have glass slide, first layer of tape, and second layer of tape.

   This incredibly simple device has created a lot of difficulty for a large number of otherwise intelligent persons. First, you cannot use "frosty" or other nontransparent tapes. Second, one should use a clean glass slide and clean (nonoily) fingers. Accept no creases or bubbles. One is building a crystal; grease, dirt, poor-quality materials, and other optical aberrances will destroy the device. Finally, be sure to use broad tape for best results. (If light can go around the edge of the crystal, the optical result will be impure.)
4. Place the first-order red compensator on top of the polarizer in the same orientation as the crystal that you are inspecting in the fluid (e.g., if the crystal goes from right to left [east to west], the first-order red compensator must be placed with its ends pointing in that same axis). Look at the *background* color of the field. The goal is a color that is variously described as magenta, pink, red, or even rust. If the background is blue or green, you can change it by lifting up the first-order red compensator and rotating the polarizer beneath it about 90 degrees. After doing this, replace the first-order red compensator in the same axis as the crystal being inspected and recheck the background color. (You may also have to rotate the analyzer to some degree.) Repeat this adjustment in decreasing degrees of rotation until you have the strongest red (or pink or magenta) that you can obtain.
5. Now look at the crystal. If it is yellow (negatively birefringent), it is a monosodium urate monohydrate crystal and the diagnosis is gout. If it is blue (positively birefringent), it is a calcium pyrophosphate dihydrate crystal and the diagnosis is pseudogout.

False Positives

Joint fluid stored in Becton–Dickinson lithium heparin tubes may contain crystals of lithium heparin, which will also be positively birefringent (blue in step 5). Triamcinolone acetate crystals in the joint fluid, either from prior therapeutic injections or from withdrawing the joint fluid through a needle or syringe that is potentially contaminated with triamcinolone acetate, will also appear blue. Cholesterol crystals from joints afflicted with rheumatoid arthritis ("gold paint" effusion) may appear blue, but these crystals are almost never needle-shaped crystals but rather broad notched rhomboid plates. Rarely, hydroxyapatite crystals may be seen in monocytes of synovial fluid from patients experiencing acute arthritis or exacerbations of osteoarthritis (although usually hydroxyapatite appears in chunks). These could be confused with either urate or calcium pyrophosphate, as hydroxyapatite crystals are both positively and negatively birefringent (Schumacher et al., 1977).

6. As a double check, you can rotate the compensator slide or the polarizer to give a blue-green background (i.e., by 90 degrees). Gout crystals that were yellow will now appear blue, and previously blue crystals will now appear yellow (Gatter, 1977).

Unstained Sputum

Gross Findings

Three-layered sputum (lipid foam, water, and cellular debris, from top to bottom) is diagnostic of retained lung secretions and purulent exudate where clearance is impaired (e.g., lung abscess or, rarely, saccular bronchiectasis).

Actinomycosis produces sulfur granules and "cayenne pepper seeds."

Of all the causes of hemoptysis, pulmonary infarction alone produces (rarely) "currant jelly."

Microscopic Findings

1. Under *low power*, one can identify macrophages (about 30 μm) and Curschmann spirals. Macrophages guarantee that the sputum is alveolar. Curschmann spirals, which are mucous plug casts of bronchioles, probably make the diagnosis of bronchial asthma.
2. Under *high dry*, one can better identify macrophages, which are usually filled with ingested debris. In smokers, the debris is often

the color of a fine maduro wrapper. One can also see Charcot–Leyden crystals (which are diagnostic of bronchial asthma) and not be concerned that one is looking at precipitated dye.

Finally, one can identify polymorphonuclear neutrophils (which indicate infection) by their multilobed nuclei. These nuclei may be distinguished from other cells with two-lobed nuclei and very large granules. The latter are eosinophils and suggest the presence of allergic diseases such as bronchial asthma.

3. Other interesting findings include the lipid-laden macrophages of lipoid pneumonia and the ciliated bronchial epithelium. The latter is seen with severe coughing from asthma or viral upper respiratory infection (Epstein, 1972).

Quellung Reaction

1. Pneumococci may be diagnosed on an unstained sputum smear by means of the Quellung reaction, provided that one has put away a supply of polyvalent antipneumococcal antiserum. Such slides may even be carried around dry (M. Mufson, *personal communication*, 1976).
2. Place one drop of the serum on the slide. Pneumococci only and always will exhibit the characteristic swelling.

Gram Stain

Invented by Hans Christian Gram to improve the visibility of bacteria in tissue sections, Gram stain has been adapted to the bacteriologic examination of a variety of body fluids, exudates, and even the buffy coat. Gram actually used aniline gentian violet instead of crystal violet and he used no counterstain. So, the answer to the question, "Who invented the Gram stain (as we presently do it)?" is, "not Gram!"

A Method

The following protocol is after Kolmer (1944) and Todd and Sanford (1948).

1. Smear a generous amount of the material on a clean glass slide with the labeled side up.
2. Allow the material to air-dry, and then fix it by passing it through a flame a few times. It is not necessary or desirable to charbroil the material.
3. Apply the crystal violet stain for 1 minute if you are using a 1.4% solution in a 1:4 mixture of 95% ethanol and 1% aqueous ammonium oxalate. If you use a 2% solution of crystal violet in methanol, you only have to stain for 30 seconds. (With stronger staining solutions, only 10 seconds may be necessary for each step.)
4. Wash off *gently* with tap water. If you are having trouble with understaining (as when using weak solutions), you may wish just to pour off the stain and omit the rinsing with tap water. If your stains are coming out with pale blue or red pneumococci, be sure to leave the stain on for a full minute.
5. Add Gram iodine (made by dissolving 1 g of iodine and 2 g of potassium iodide in 300 mL of distilled water) for at least 30 seconds (or at least until the smear appears black.)
6. Decolorize the Gram-negative bacteria by applying the decolorizer (acetone, ethanol, or a 1:1 mixture of the two) until no further blue stain floats off the slide. This can take from 15 seconds to 2 minutes. (Overdecolorizing[5] is usually not the result of leaving the decolorizer on too long, but of the deterioration of the iodine solution in step 5 caused by light exposure. It may be rejuvenated with a pinch of baking soda.)
7. Wash with tap water and counterstain with 1% safranin (10 mL of saturated alcoholic safranin solution in 90 mL of water) for at least 30 seconds and preferably for 1 minute if you wish to see the *Haemophilus* coccobacillus lying in the proteinaceous background. (Actually, you can use almost anything for the counterstain, even the carbol-fuchsin from the acid-fast stain kit.)
8. Wash with tap water, dry, and observe. The nuclei of leukocytes should be red, not blue as with the Wright stain. If they are blue, you left the crystal violet on for too long or the decolorizer was not enough. The stain may be variable in different regions of the slide, and the same coccus may be negative in one area and positive in another, so use the leukocyte nucleus color as a local control.

Pleural Fluid: Selected Topics

1. The diagnosis of tuberculous pleural effusion is often missed because the few antigenic tubercle bacilli that set off the allergic effusion are usually not found. To overcome this problem, let the fluid sit for some time, and a pellicle will form at the top of the fluid. This coagulum may actually contain the tubercle bacilli.
2. It is said that the pleural effusion of tuberculosis is *never* accompanied by mesothelial cells; however, exceptions have been seen (Light et al., 1973).
3. To determine whether anatomically deformed lymphatics are contributing to the formation of body fluids, such as a rapidly reaccumulating pleural effusion, have the patient eat a few ice-cream cones before the next thoracentesis, and see whether the fluid becomes lactescent. Opalesence due to a chylous effusion (as opposed to debris) can be extracted into ether. (Do not forget that ether is flammable or explosive). The same trick works with ascitic fluid.

Ascitic Fluid

Gram stain of the buffy coat of ascitic fluid is invaluable in the diagnosis of a disease notoriously difficult to diagnose: spontaneous bacterial peritonitis. Here, the sensitivity is 55% (Hoefs and Runyon, 1985). For comparison, only 24% of such patients are culture positive on admission.

The advantage of the test is not only that it makes the diagnosis but that it also provides instantaneous morphologic information useful in providing guidance for immediate therapy.

Cerebrospinal Fluid

Subarachnoid Hemorrhage versus Traumatic Taps

Subarachnoid hemorrhage is characterized by blood in the cerebrospinal fluid (CSF), but so is a traumatic tap. If the blood clears by the time the third or fourth tube is collected, traumatic tap is the

[5] Manifested by all red organisms—even the pneumococcus!

diagnosis, whereas if the supernatant is xanthochromic, the blood has been in the CSF for at least 12 hours or is present in large quantities.

There are equivocal cases in which the measurement of a CSF bilirubin will be helpful, since in a traumatic tap, the blood will not have had time to be metabolized by the reticuloendothelial cells into bilirubin (the source of the xanthochromia of the crude test above).

Caveats

1. Jaundiced patients have bilirubin in the CSF, so this test for xanthochromic is not helpful.
2. You must determine some normal CSF bilirubins to get the baseline normal "ceiling" for each laboratory. This value is about 0.40 mg per dL but varies from automated laboratory to laboratory and even between machines and methods in those laboratories that have more than one machine or method for the automated determination of bilirubin.

A Weekend Method for Concentrating CSF Cells

The weekend method is useful if the cytospin is not available on the weekend when the patient has his lumbar puncture.

1. Take a glass slide and mark a target area about 1 cm in diameter (the inner diameter of the rubber washer to be used in step 3) on the *bottom* of the slide with a wax pencil.
2. Take a piece of bibulous paper and cut a hole that matches the size of the target. Cover the slide with the paper, with the hole over the target area (Fig. 28-4).
3. Place a rubber washer on top of the hole in the paper.
4. Place the fluid in a 3-mL syringe from which the plunger has been removed.
5. Place the syringe over the rubber washer. (You may want to clamp this all together, on a ring stand, for instance.) Allow the fluid to drip down into the well made by the rubber washer. The liquid will freely diffuse laterally through the bibulous paper, leaving the cells in the well, just over the spot marked by the crayon. The protein in the CSF will fix the cells to the glass. If the fluid is not to be stained immediately, it can be refrigerated and stained by the technician on Monday morning.

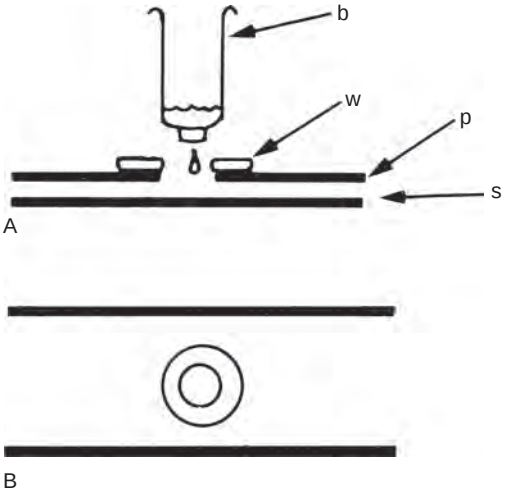

Figure 28-4 Apparatus required for concentrating cerebrospinal fluid cells. **A:** Side view; b, barrel of the syringe; w, washer, with a section taken through the center; p, paper; and s, glass slide. The paper appears not to be touching the slide, but in practice lies right on top of it. **B:** Top view with the syringe removed. The "doughnut" is the washer. The center of the doughnut would be glass, and all the area peripheral to it would be paper over glass.

Plasma cells are seen in the CSF in myeloma, brain abscess, cerebral metastases, and after and during aseptic meningitis (Bosch and Oehmichen, 1976; Glasser et al., 1977; Manconi et al., 1978; Sato et al., 1986).

Eosinophilia of the CSF, an unusual finding, may signify a parasitic infection. Other less common causes include fungal meningitis (*Coccidioides immitis*); meningitis due to mycobacteria, *Treponema pallidum*, or rickettsia; malignancy (lymphoma); allergic reaction to foreign bodies; and the hypereosinophilic syndrome. Recently it has been described in neurosarcoidosis (Scott, 1988).

Fat Staining

Fat staining of the CSF is a good way to diagnose fat embolism (Cross, 1965) (also see urine, above; however, fat staining of the sputum gives a large number of false positives).

The use of glucose detection tape for diagnosing CSF rhinorrhea is discussed in Chapter 12.

Stool Examination for Pancreatic and Small-bowel Malabsorption

A Method

1. Smear a smidgen of stool (e.g., from the rectal examination) on a glass slide.
2. Mix one drop of glacial acetic acid into it.
3. Add one drop of a fat stain. (Sudan III, Sudan IV, or scarlet red have all been used; I use the first.)
4. Place a coverslip on top of the mixture and gently heat over a flame (or in the microwave oven) so that any fatty acids present will melt. If using a flame, take care not to smoke the slide, boil it, or ignite the alcohol in the stain.
5. Allow the slide to cool for about 10 minutes. This will let any (unstained) fatty acids crystallize out as thin needles, usually in bunches. (On the other hand, the triglycerides will be stained with Sudan III as round orange globules, provided you did not burn the slide.)

Interpretation

1. If one sees *only* fatty acid crystals, the diarrhea is caused by intestinal insufficiency, as the pancreatic enzymes have digested the triglycerides into fatty acids but the fatty acids have not been absorbed.
2. If there are large numbers (more than 12 per high-power field at high dry) of orange globules, one is dealing with pancreatic insufficiency. (In this situation, colonic bacteria may metabolize *some* of the triglycerides into fatty acids, which are not absorbed by the colon. However, the predominant form is still the orange globule.)

With pancreatic insufficiency, two double checks are available. First, in addition to insufficient lipase, there is undoubtedly

insufficient luminal carboxypeptidase. In that case, dietary meat fibers (muscle fibers) may be seen in the stool.

Muscle fibers may also be seen in the stool of patients who masticate poorly, but these fibers will have rounded ends (where the pancreatic carboxypeptidase has attempted to compensate for insufficient maceration), whereas with pancreatic insufficiency, the meat fibers will have sharp ragged edges (indicating that mastication was good but not much further happened in the lumen of the gut).

If the muscle fibers are only of the skeletal type (nonbranching), the patient has been eating the better cuts of meat. If the muscle fibers are branched (as in smooth muscle and heart muscle), however, the patient has been eating the cheaper cuts of meat, such as chitlings, sausages, and salamis other than andouille. It is amazing how many people will bet that you cannot "guess" what kind of meat the patient had the day before he entered the hospital.

The second check for pancreatic insufficiency is that microscopic octahedral starch crystals (which can possibly be confused with sardine scales) will appear in the stool. When in doubt, add a drop of Lugol solution or Gram iodine to a smidgen of stool. Only starch crystals will appear gray-black (Todd and Sanford, 1948).

False Negatives

Although some persons have such minimal disease that it may not be detected by this method, others have been taught in the school of experience that certain foods produce symptoms, and so have altered their dietary intake to avoid the offending materials, often unconsciously.

Obviously, if nothing has gone into the top of the tube, you will not be able to detect anything at the bottom of the tube. Accordingly, one should arrange for a hasty food emporium to provide a few preparatory meals consisting of a burger (for meat fibers), an order of fries (for the starch granules), and a shake (for the triglycerides).

Similarly, this screening test should be performed before the barium enema. The latter does not alter the physiology, but so adulterates and displaces the native stool that nothing can be seen under the microscope but the bland and boring lunar terrain of barium salts.

Another type of false negative occurs in protein-losing enteropathy, in which the tests, including the one for meat fibers, will be completely negative. In these diseases (such as Ménétrier disease), the gut is losing only protein molecules, which cannot be seen microscopically. The pancreatic hydrolytic function and the absorptive function are both intact, but the absorptive function is overwhelmed by the outpouring of fluid.

False Positives

The use of suppositories, mineral oil, and dietetic salad dressing may all cause false positives for triglycerides.

A Caveat

Until one gains some experience with this test it may be necessary to compare results with a quantitative stool fat determination. The correlation is excellent (Drummey et al., 1961). Alternately, one could learn at the elbow of one who has done the test, but as the paper heralding the rediscovery of this technique is already older than most residents, such instruction is rarely available.

Vaginal Secretions

The examination of vaginal secretions for infection is discussed in Chapter 22 (see Table 22.1).

The Ice Water Test for Pericardial Disease

Following the ingestion of 750 mL of ice water, normal subjects and patients with heart disease (regardless of cardiac enlargement) show (at 3 to 5 minutes) a decrease in the T wave amplitude in leads 2, 3, and aVF, and an increase of T wave amplitude in aVL, aVR, V_1, V_2, and V_4. This normal effect of cold stimulation on the T wave vector is minimal or absent in subjects in whom the heart muscle is thermally insulated by fluid, inflammation, or pericardial thickening (Friedman and McClure, 1962).

The Future of Diagnostic Testing

While enormous strides have been made in diagnostic imaging and in expensive laboratory tests for specific conditions, the same basic biochemical profiles are being done in 2009 as when this author was in medical school in the 1970s. Clinicians pore over printouts that show whether each value is "normal" or "abnormal" based on whether it is within a range of two standard deviations from the laboratory's mean—even if the values have a bimodal or trimodal rather than a Gaussian distribution function. There is no information concerning the pattern of results on multiple tests, and indeed results available from multichannel analyzers are actually *suppressed* lest the laboratory or clinician be accused of performing unnecessary tests, now a crime punishable by heavy fines or even imprisonment. This is said to be a cost-saving measure, even though the marginal cost of this additional information is virtually zero, and the analysis is done although the results are not reported.

Our ability to sequence the genome is touted as a great breakthrough, and indeed it is a stunning achievement. It is, however, of virtually no help in routine clinical practice. Its primary applications are in forensics, early recognition of genetic defects, or perhaps in producing "designer babies." It is, of course, extremely expensive. Using genomics as a diagnostic tool would be like trying to diagnose a leak in your roof by studying the blueprints for the house.

Financial expert Andy Kessler, who made nearly a billion dollars riding the technology wave in the 1990s, wrote a book on the prospects of sophisticated tools such as computer chips imbedded with monoclonal antibodies. He looks forward to the day when "rubber-hammer-wielding doctors" will be obsolete (Kessler, 2006). His focus on the proteome rather than the genome contrasts with that of biochemist Arthur Robinson, who looks at the "metabolome" (Orient, 2007).

With technology available in the 1970s and much more highly developed now, it is possible to produce a complete breakdown of the end-products of metabolism found in body fluids, including blood, urine, and breath, at very low cost, using mass spectrometry. Sophisticated pattern analysis has the potential to diagnose risk of disease, as well as active disease, and to follow the individual patient's state of health and disease with great precision. Robinson envisions an analyzer the size of a laser printer in patients' homes

or shopping malls. Very frequent urine profiles could be obtained and sent by internet to consultants anywhere in the world, and the results of therapeutic interventions in each patient could be known immediately (Robinson, 2007).

In this author's opinion, such innovations would enable a revolution in medicine. Personalized, patient-centered diagnostics would replace the current trend toward treating patients as interchangeable cost or profit centers using protocols derived from population-based statistics. The doctor could devote his whole attention to his traditional role—to teach, to counsel, to do necessary procedures—rather than to churn, to certify, to code, to comply, to document, and to keep the gate.

Perhaps readers of this book will bring about that revolution.

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CHAPTER

29

Annotated Bibliography

You go back to the classics of a subject for the practical purpose of saving yourself a lot of work. You get an accumulation of observation, method, and technique that subsequent experience has confirmed, and you can take it at secondhand and don't have to work it all out afresh for yourself. Maybe you can improve on it, here and there, and that is all right, but if you don't know the classics of your subject, you often find that you have been wasting a lot of time over something that somebody went all through, clear back in the Middle Ages. . . .

. . . When I was at Ems a couple of years ago, one of their experimenters had just discovered that the Ems salts helped out a little in cases of pyorrhea. That was known four hundred years ago. It is mentioned in a report on the springs, written in the sixteenth century. Then it was forgotten, and discovered again only the other day.

—Albert Jay Nock, *Pantagruelism*, a speech to the faculty of medicine at Johns Hopkins, October 28, 1932, the 400th anniversary of the publication of *Pantagruel*

The work of M. Laënnec is a book eminently practical, but we fear that its length can only be a great obstacle to its utility.

—A French review by L. Rouzet, January, 1820 cited in *Thorax* 1981:36:487–492.

Most of the following textbooks have been referred to throughout this work. They may be recommended, provided that the reader understands that each is faulted by undocumented statements, elision, or in many cases simply the passage of time. Nevertheless, each has its virtues. Dr Sapira's comments are in brackets or parentheses. An update concerning the latest edition follows, if applicable. Students fortunate enough to have access to a library that keeps old books in its stacks might find it instructive to look at the editions referenced here.

Adams FD. *Physical Diagnosis*. 14th Ed. Baltimore, MD: Williams & Wilkins; 1958, reprinted 1961, 962. [This was the last version of the text originally written by Cabot (*vide infra*) until it was resurrected in 1974 by Burnside. The current incarnation of Cabot's original work can be read much more quickly than that available a quarter century ago, having only 223 pages versus 926 in the 1958 edition. The pagination sequences indicate the decrepitude of American medical education regarding clinical examination.]

Alexander I. The neurologic examination. *Pullen's Medical Diagnosis*, last published in 1950. [This book is difficult to find. The present work makes use of some of the illustrations.]

"Bailey," Clain A, ed. *Hamilton Bailey's Demonstrations of Physical Signs in Clinical Surgery*. 15th Ed. Baltimore, MD: Williams & Wilkins; 1973, 572. [This is an example of a masterpiece that has outlived its author, and is still called "Bailey" even though Clain is now the editor. It is a benchmark work both in the quality of its illustrations and in the number of editions and sales. It is a true chrestomathy—it does not really teach a systematic approach, and the picture of examining equipment used within its pages does not even include a stethoscope (although this instrument is mentioned in the 16th edition), let alone an ophthalmoscope!] Now edited by John S.P. Lumley, the 18th edition (1997) was described as a "photographic atlas" and the 19th (1999) as a "self-assessment picture test book."

Baker AB, Joynt RJ. *Clinical Neurology*. revised ed. New York: Harper & Row; 1986. ["Baker" remains a clearly written, authoritative description of neurologic diseases.]

Bauer J. *Differential Diagnosis of Internal Diseases*. New York: Grune & Stratton; 1967. [Another single-authored refutation of the notion that there is "too much knowledge" for one person to be broadly competent.]

Cabot RC. *Physical Diagnosis*. 11th Ed. Baltimore, MD: William Wood and Company; 1934, 540. [The first edition of this work came out in 1900. The last edition that Cabot wrote by himself was the 11th. I used this work well into the 1980s until one day it grew legs and walked out of my office. In 1938, Cabot took a partner, F.D. Adams, who wrote the 13th edition by himself: *vide supra*. Cabot was a Harvard medical student rooming with a law student, who was rehearsing for mock trials. Cabot transferred the mock trial to medicine and thus concocted the CPC, the clinicopathologic conference. One of the best teaching devices ever invented, it is currently in eclipse because of its antinarcissistic effects and the intellectual demands it makes on the participants.]

Cassell EJ. *Talking with Patients: Volume 2, Clinical Technique*. Cambridge, MA: MIT Press; 1985. [An illustrative passage: "It is sad that even during the period when this crucial technique (interviewing) is being learned, most instructors never listen to their students taking an entire history. The reason usually given for this lapse in teaching is, of course, that the process takes so long. Can you imagine a surgeon saying that surgeons in training are not supervised for a whole operation because it takes too long?"] This edition is still in print.

"Cope," Silen W, ed. *Cope's Early Diagnosis of the Acute Abdomen*. 15th Ed. New York: Oxford University Press; 1979, 280. [The first edition by Sir Zachary Cope appeared in 1921; the book, like "Bailey," has happily outlived the author, who died in 1974. Although the posthumous edition has been revised by an American surgeon, William Silen, it is still known as "Cope." If American medical students were forced to use this book, it would probably modify their

behavior as practitioners to the extent that millions of dollars could be saved annually in unnecessary presurgical studies. Acknowledged to be a classic by the medically literate, it reminds me of the wag's definition of a classic—something everybody should read but no one does.] The book is now in its 21st edition (New York: Oxford University Press; 2005, 644.) and still going strong.

DeGowin EL. *Bedside Diagnostic Examination*. New York: Macmillan; 1965, 687. [DeGowin was the spiritual successor to Adams but had the misfortune to appear just a few years before that revolution in American medical education (1968) that the present author views with such dismay. Owing to the educational times, "DeGowin" never had the sales that it deserved. The most recent edition as of 1990, by Richard DeGowin (the father, Elmer, having died), had a slightly different format, which can make it hard to find things, but DeGowin was for two decades the benchmark for physical diagnosis texts.] Now in its 9th edition (McGraw-Hill;2008, 944, paperback only), by Richard LeBlond, Donald Brown, and Richard DeGowin, it has been completely revised.

DeJong RN. *The Neurologic Examination*. 4th Ed. New York: Harper & Row; 1979. [In <800 pages of clearly written text, here is everything you need to know.] The 5th edition (1992) was updated by A.F. Haerer, one of DeJong's students. The 6th edition, by William W. Campbell (Lippincott Williams & Wilkins; 2005, 641) is described as "heavily revised."

Dorland's Illustrated Medical Dictionary. 23rd Ed. Philadelphia, PA: W. B. Saunders; 1957.

Dyck PJ, Thomas PK, Lambert EH, et al. *Peripheral Neuropathy*. 2nd Ed. Philadelphia, PA: W. B. Saunders; 1984. [The bible on peripheral neuropathy. There are 2,323 pages in two volumes.]

Forgacs P. The functional basis of pulmonary sounds. *Chest*. 1978;73:399–405. [Forgacs cites his own classic studies.]

"French's," Hart FD, ed. *French's Index of Differential Diagnosis*. 12th Ed. Bristol: John Wright and Sons; 1985, 1,032, *French's Index of Differential Diagnosis*. 13th Ed. Arnold Publishers; 1996, 812. [Affectionately known as "French's," this is a rather complete listing of the diagnostic possibilities for certain leading signs and symptoms. First published in 1912, its continued existence should serve as a refutation to those troglodytes who think medicine can be reduced to protocols.] The 14th edition (Hodder Arnold; 2005, 864) is edited by Mark Kinirons and Harold Ellis, and is available in paperback only.

Friedberg CK. *Diseases of the Heart*. 2nd Ed. Philadelphia, PA: W. B. Saunders; 1956, 1,161. [After all these years, this is still a better sourcebook for much clinical cardiology than the popular multiauthored texts that have succeeded it in time but not in heuristic worth.]

Hillman RS, Goodell BW, Grundy SM, et al. *Clinical Skills: Interviewing, History Taking, and Physical Diagnosis*. New York: McGraw-Hill; 1981, 399. [This book is strong on the interview; the physical examination, in spots, is treated in a somewhat cavalier manner.]

Judge RD, Zuidema GD, eds. *Physical Diagnosis: A Physiologic Approach to the Clinical Examination*. 2nd Ed. Boston, MA: Little, Brown; 1963, 495. [More recent editions, which include Dr Faith Fitzgerald's contributions, represent a great improvement.]

Leopold SS. *The Principles and Methods of Physical Diagnosis*. Philadelphia, PA: W. B. Saunders; 1952, 430. [A great deal of Norris and Landis (*vide infra*) went into this much shorter work.]

"Major," Delp MH, Manning RT, eds. *Major's Physical Diagnosis*. Philadelphia, PA: W. B. Saunders; 1975, 759. [Anything with Major's name on it is well written. The decline in this work's popularity is more a reflection on the changing audience than on the new editors.]

Morgan WL Jr, Engel GL. *The Clinical Approach to the Patient*. Philadelphia, PA: W. B. Saunders; 1969. [Although this is not much of a physical diagnosis book—nor does it claim to be—for explication and emphasis of those clinical and interpersonal skills needed by the junior clerk, this book still has no peer.]

Norris G, Landis HRM. *Diseases of the Chest*. 6th Ed. Philadelphia, PA: W. B. Saunders; 1938, 1,019. [This is actually a textbook of physical diagnosis confined to the lungs and heart. The authors produced over 1,000 referenced, well-written, well-organized, practical pages on the physical examination of these two organs. This work was highly scientific for its time, and when compared with contemporary physical diagnosis texts, is still rather scholarly. Note that the date of publication preceded the phonocardiogram, so all the cardiac auscultation graphics consist of what the authors heard and taught.]

Perloff JK. *Physical Examination of the Heart and Circulation*. Philadelphia, PA: W. B. Saunders; 1982, 278. [This work is so good that it makes other medical writers jealous. Its strength is that the author has actually done that which he writes about and is not merely repeating what others have written. Furthermore, he has the perspective required to deal effectively yet gracefully with some of the silliness of physical examination pedantry and the writing skill to do so briefly. There are also excellent references to the works of others but not so many as to make the style tedious.]

Pinel P. *The Clinical Training of Doctors: An Essay of 1793*, edited and translated with an introductory essay by DB Werner, Baltimore, MD: Johns Hopkins University Press; 1980, 102. [An essay from 1793 lost for decades because of a series of historic accidents. Its timeliness is uncanny. This is the same Pinel who is better known, although erroneously, for taking the chains off patients in the Bicêtre asylum.]

Prior JA, Silberstein JS. *Physical Diagnosis*. St. Louis: CV Mosby; 1959, 388. [Recent editions have been much improved by Havener's chapter on ophthalmoscopy.]

Roberts HJ. *Difficult Diagnosis: A Guide to the Interpretation of Obscure Illness*. Philadelphia, PA: W. B. Saunders; 1958, 913. [This one-author tour de force is an example of the outstanding thinking available to medical students of my generation. The author never published a second edition. A present multiauthored volume of the same name is less useful except to illustrate that, whereas formerly there was not "too much knowledge" for one person to master, presently there may be too many "experts" to permit breadth and perspective in a medical work.]

Sapira JD, Cherubin CE. *Drug Abuse*. New York: American Elsevier; 1975. [A useful guide to medical diseases of the drug abuser.]

Snapper I, Kahn AI. *Bedside Medicine*. 2nd Ed. New York: Grune & Stratton; 1967. [This text is referred to as "Snapper" because he was the famous sole author of the first edition of this work. Kahn was the silent junior author acknowledged at the time of the second edition. This text is a masterpiece of clinical detective work utilizing the disease concept, with emphasis on knowing the natural history of the disease, the history of the patient, and the physical findings.]

Stern TN. *Clinical Examination*. Chicago: Year book Medical Publishers; 1964. [Since one may now be a diplomate of both the National Board of Medical Examiners and the American Board of Internal Medicine, with no external evaluation of one's clinical examination skills, pleasant single-author books like this one, once so plentiful, have disappeared, there being so little audience for them. The professors of my medical school were apparently right when they predicted that the disease would replace the patient as the focal point of university medicine. See also Altschule MD. *Essays on the Rise and Decline of Beside Medicine*. Philadelphia, PA: Lea & Febiger for Tots Gap Medical Research Laboratories, Inc.; 1989.]

Stevenson I. *The Diagnostic Interview*. 2nd Ed. New York: Harper & Row; 1971, 273. [A single volume that effectively instructs in both interviewing and history taking. Highly recommended for the person who wishes to be a physician rather than a "health care provider."]

Wiener SL, Nathanson M. [This refers to a series of articles that appeared in the journal *Medical Times* during the winter-spring of 1976 to 1977. This series was abstracted from a full-length manuscript about frequently observed errors in the history and physical. A very brief version of this work also appeared in *JAMA*, but as far as I can determine, the complete manuscript was never published.]

Wood P. *Disease of the Heart and Circulation*. 2nd Ed. Philadelphia, PA: JB Lippincott; 1956, or 3rd Ed, 1968, 1,161. [The third edition was actually produced as a labor of love by his former students and colleagues, but the second edition was written only by Wood.]

And so here, O Reader, has the time come for us two to part. Toilsome was our journey together; not without offence; but it is done. To me thou wert as a beloved shade, the disembodied or not yet embodied spirit of a Brother. To thee I was but as a Voice. Yet was our relation a kind of sacred one; doubt not that! For whatsoever once sacred things become hollow jargons, yet while the Voice of Man speaks with Man, hast thou not there the living fountain out of which all sacredness sprang and will yet spring? Man, by the nature of him, is definable as "an incarnated Word." Ill stands it with me if I have spoken falsely; thine also it was to hear truly. Farewell.

—Carlyle, *The French Revolution*, Finis

Good night, gentlemen. Perdonatemi, and don't be thinking too much about my faults, since yon are not in the habit of giving any too much thought to your own.

—Rabelais, *First Book of the Pantagruel*

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